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OFFICE OF NAVAL RESEARCH SCIENTIFIC LIAISON GROUP AP--ETC F/G B/G  
ONR TOKYO SCIENTIFIC BULLETIN, VOLUME 6, NUMBER 1, JANUARY-MARC--ETC(U)  
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JANUARY TO MARCH 1981

VOL. 6, NO. 1

# SCIENTIFIC BULLETIN

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1. REPORT NUMBER ONR/T VOL 6, NO 1	2. GOVT ACCESSION NO. AD-AC 99166	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ONR TOKYO SCIENTIFIC BULLETIN.	5. TYPE OF REPORT & PERIOD COVERED	
6. AUTHOR(s) Young B. Kim, Scientific Director Mary Lou Moore, Editorial Assistant	7. PERFORMING ORG. REPORT NUMBER	
8. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Naval Research Scientific Liaison Group American Embassy APO San Francisco 96503	9. CONTRACT OR GRANT NUMBER(s)	
10. CONTROLLING OFFICE NAME AND ADDRESS	11. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
12. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	13. REPORT DATE January-March 1981	
	14. NUMBER OF PAGES	
	15. SECURITY CLASS. (of this report) UNCLASSIFIED	
	16a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report)  APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Semiconductors People's Republic of China Metal-semiconductor interfaces Commission of Coastal Environment (CCE) Marshy shorelines Coastal studies Sandy shorelines Coastal Dunes Artificial structures on shore processes		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This is a quarterly publication presenting articles covering recent developments in Far Eastern (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be of value to scientists by providing items of interest well in advance of the usual scientific publications. The articles are written primarily by members of the staff of ONR Tokyo,		

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19. Key Words (cont.)

Gaseous electronics research	High pressure research
Electron mobilities	Extremely low temperatures
Ion mobilities	Ultra high vacuum
Electron diffusion coefficients	Extremely high temperatures
Ion diffusion coefficients	Low level radioactivity
Arcs	Environmental radioactivity
Time-temperature indicators	Geochemistry
Superconductors	Geochronology
Organic metals	Rolling low level radioactivity
Artificial muscles	laboratory
Molecular memory devices	Shoreline erosion
Solitons in condensed matter	Japanese shoreline modification
Physics	Shoreline protection
Muscle contraction	
Proteins	
Myosin	
Actin	
Adenosine triphosphate	
Computers, fault-tolerant	
Integrated circuits	
Electronic design	
Redundancy	
Geophysics	

20. Abstract (cont.)

with certain reports also being contributed by visiting stateside scientists. Occasionally a regional scientist will be invited to submit an article covering his own work, considered to be of special interest.

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## CONTRIBUTORS

Harley J. Walker is Boyd Professor in the Department of Geography and Anthropology at Louisiana State University. He just completed a nine-month visit as a Japan Foundation guest professor at Tsukuba University. Dr. Walker's interests lie in the areas of arctic hydrology, coastal morphology, and coastal defense systems.

Donald W. Davis is an Associate Professor in the Earth Science Department at Nicholls State University in Louisiana. He received his doctorate from Louisiana State University in 1973. Most of his research concerns the wetlands, especially human utilization and modification of Louisiana marshes and swamps.

Leon H. Fisher, presently on the staff of ONR Tokyo, is on leave from California State University, Hayward. He recently completed an eight-year assignment as Dean of Sciences at Hayward, where he is also Professor of Physics. Dr. Fisher has held professorships at New York University and at the University of Illinois, has led research groups at the Lockheed Palo Alto Research Laboratory and the General Telephone and Electronics Laboratory, and has been visiting professor at the University of California, Berkeley, the University of Washington, and the University of Southern California. His specialty is gaseous electronics, and his interests include ionization coefficients.

Francis A. Richards is Professor of Oceanography at the University of Washington. Dr. Richards' research interests in chemical oceanography include analysis of seawater, plankton pigments, oxygen-deficient and sulfide-bearing environments in the ocean, and interrelationships among the branches of oceanography through chemistry. He served on the staff of ONR Tokyo from 1977 to 1979 and again in the summer of 1980.

Leonard J. Brillson received his Ph.D. in Physics from the University of Pennsylvania in 1972. Between 1969-1972, he held a National Science Foundation Fellowship while pursuing a program of experimental solid state research. In 1972 he joined Xerox Webster Research where he is now a Senior Scientist of the Research Staff. His research interests include fundamental studies in surface physics, interfacial chemistry, photoconductivity, light scattering, and optical and electronic spectroscopy. Dr. Brillson is a member of the American Physical Society and the American Vacuum Society.

Dale G. Platteter is an Electronic Engineer at the Naval Weapons Support Center, Crane, Indiana, where he is engaged in advanced component research for the Navy's Standard Electronic Module (SEM) Program. Mr. Platteter received his BSEE degree from the University of Wisconsin in 1972 and since then has authored technical papers in the fields of microprocessor applications, integrated circuit testing, and semiconductor failure analysis. He is currently working on fault-tolerant electronic module design techniques for the TRIDENT Missile Program.

Earl F. Skelton is Head of the Phase Transformation Section at the Naval Research Laboratory and is currently on sabbatical leave at the Stanford Synchrotron Radiation Laboratory, Stanford University. Several years ago he spent four months in Japan reviewing the status of high pressure science and technology. Following the Second U.S.-Japan Seminar on High Pressure Science held recently in Hakone, he had an opportunity to again review the Japanese high pressure scene. He is a research physicist with interests in phase transformations, superconductivity, and x-ray diffraction phenomena.

William A. Little is Professor of Physics at Stanford University. Dr. Little received a Ph.D from Rhodes University, South Africa and University of Glasgow. Dr. Little was invited professor at the University of Geneva, 1964-1965. His research interests are organic fluorescence, magnetic resonance, low temperature physics, phase transition, and chemical physics. Professor Little is a Alfred P. Sloan Fellow and a Guggenheim Fellow.

Kazumi Maki is Professor of Physics at the University of Southern California. He holds a Ph.D. from Kyoto University, Japan. Dr. Maki has also held a professorship at Tohoku University, Japan. Research interests are the theory of condensed matter physics and theory of superconductivity and charge density wave.

Seikoh Sakiyama, Scientific Affairs Specialist of ONR Tokyo, has had considerable industrial experience in laboratory chemistry, electronic instrumentation, and quality control methodology. His interests include computer science, linguistics, and energy technology.

Rudolph J. Marcus is a chemist at the ONR Western Regional Office in Pasadena. Dr. Marcus was Scientific Director of ONR Tokyo from March 1979 until Dec 1980. His interests include photochemistry, photophysics, and computer control of chemical experimentation. Dr. Marcus served as founding secretary of the American Chemical Society's Division of Computers in Chemistry (1974-79). His papers on photochemical energy conversion in the 1950s are still being cited.

# CONTENTS

	Page
In Defense of an Island: Japan ..... Harley J. Walker	1
The Field Symposium of the Commission on the ..... Coastal Environment: Japan, 1980 Harley J. Walker and Donald W. Davis	10
Gaseous Electronics Research in Australia ..... Leon H. Fisher	23
Low Level Radioactivity Laboratory, Kanazawa University ..... Francis A. Richards	43
Leading Semiconductor Research in China ..... Leonard J. Brillson	48
The Tenth International Symposium on Fault-Tolerant Computing ..... Dale G. Platteter	52
Second U.S.-Japan Seminar on High Pressure Research ..... Application in Geophysics	64
High Pressure Research in Japan: An Update ..... Earl F. Skelton	71
Informal Report on the Conference on the Design of Molecular Structures: ..... Molecular Systems for Electronic Devices William A. Little	79
Informal Report on the Soliton Conference in Japan ..... Kazumi Maki	83
International Meetings in the Far East 1980-1983 ..... Seikoh Sakiyama	85
The Tenth International Symposium on Fault-Tolerant Computing ..... International Conference on Automated Multiphasic Health ..... Testing and Services	98 108
Seventh International CODATA Conference ..... Rudolph J. Marcus	117

Cover: 1981 is the year of the bird, the tenth of the twelve year horary. In the Orient, the crane symbolizes purity and loftiness. This is a photographic reproduction of an Oriental painting done by a Korean artist, Young-Sang Shin, who also teaches art at Seoul National University.

## IN DEFENSE OF AN ISLAND: JAPANESE STYLE

H. J. Walker

Japan, consisting of four large and nearly 4000 small islands, has a shoreline that is very diverse, subjected to highly varied and often extreme natural processes, densely peopled, and intensively used. It is little wonder that the Japanese have modified it to a greater extent than almost any other people. Much of this modification has been, and is being, done for the purpose of protection-protection of the shoreline from further erosion, protection of vast investments within the coastal zone, and protection of life during extreme events such as typhoon surges and tsunamis.

The modification of the shoreline of Japan has proceeded to such an extent that today (1980) less than half of the length of the four major islands of Hokkaido, Honshu, Shikoku, and Kyushu are now considered to be in a natural state. In 1980 the Japanese Environmental Agency issued the following data:

TABLE 1. Present Status of Japan's Coastline (1978-1979)

	Natural	Semi-Natural	Manmade	Rivermouth	Total
Major Islands	9146.3 km 49.0%	2905.0 km 15.6%	6367.5 km 34.1%	239.4 km 1.3%	18,658.2 km
Smaller Islands	9820.9 km 72.7%	1435.4 km 10.6%	2231.5 km 16.5%	24.2 km 0.2%	13,512.0 km
Total	18967.2 km 59.0%	4340.4 km 13.5%	8599.0 km 26.7%	263.6 km 0.8%	32,170.2 km

The release of the above summary, along with coastal data for each of Japan's prefectures, served as the basis for numerous newspaper articles around Japan during late summer 1980. Prefectural proportions vary greatly. In Iwate prefecture some 86% of the coast is still considered natural and in Shimane prefecture it is 77%; in contrast, none of the shoreline in the Tokyo Metropolitan area is now natural and in Osaka prefecture the value is less than 2%.

This paper is intended to illustrate the extent to which the Japanese go in the cause of erosion control and some of the procedures used in defending their limited space from the sea. The setting is a small island located one kilometer from the mainland in southeast Hokkaido (Figure 1). Although, in the 1980 statistics referred to above, Hokkaido is listed as having 66% of its coast in the natural state, Figure 1 shows that shoreline erosion (as of 1980) is extensive and that coastal protection works (1973 locations) are numerous. Since 1973 many new locations have been added and the protective structures at most 1973 locations expanded. The island of Kojima (a Japanese name meaning "small island") is an example of the latter-i.e., where additional protective structures have been constructed since 1973.

I had the pleasure of visiting this island in August 1980 with Dr. Masao Inokuchi, Director, Environmental Research Center, Tsukuba University; Dr. Shiro Furukawa and Mr. T. Sasaki, Professor and Assistant Professor respectively at University of Hokkaido, Kushiro Branch, and several members of the Akkeshi Branch, Public Works Division, Hokkaido Government. The following is based on discussions with these informants and on

maps, diagrams, and photographs supplied by the East Hokkaido Visitor's Association.

The coastal waters along this part of Hokkaido are important fishing grounds. Kushiro (Figure 1), the largest city in the area's, is one of Japan's leading fishing harbors. One of the areas most important marine related activities is the harvesting and processing of konbu, a type of seaweed that is a prized food item in Japan. It is, and has been for at least a century, the mainstay of Kojima.

Kojima is a small island (about five hectares or 12 acres) that is nearly rectangular in shape with a narrow elongated hill of mainly Tertiary shale for its eastern end (Figures 5 and 7). This ridge which rises to over 30 meters in height faces the open Pacific and is subjected to an almost unlimited fetch. In this part of Hokkaido the prevailing wind directions are SSE, S, and NNE each for about 13% of the time. Winds of over 15 m/sec occur from the S over 4% of the time. Those waves generated by winds between the E and SW quadrants are especially significant. This coast is also subjected to occasional storm waves and even tsunami (Figure 1). Thus, it is not surprising that the ocean facing portion of the ridge is subject to high wave energy.

Because of the barrier the hill provides against storm waves a circular shingle bar has developed downdrift. It has been a bar of highly variable shape and size through the years. Just how much it changed in the years prior to the first aerial photograph (1947) is uncertain. However, if the 1922 topographic map at a scale of 1/50,000 is accurate the hill was reduced in length to about half (from over 400 m to 220 m) and the islands area to less than one-third between the early 1920s and 1958 (the date of the first 1/25,000 topographic map of the area). In comparing these two maps several other conclusions can be drawn, including: (1) the width of the island has changed little (when taken as a cross-section normal to the center of the hill) and (2), the northern end of the hill has been eroded more rapidly than the southern end.

Subsequent changes are shown on Figure 2 which is based on the comparison of four sets of aerial photographs.

Because of the position of the ridge and the occurrence of a submerged platform toward the open sea from it, wave refraction and diffraction can cause erosion on the "slides" of the island. It is apparently because of such erosion that the island received its first major protective structure-a seawall along its northeastern corner (Figure 2).

This seawall was followed four years later by the initiation of the construction of a series of groins from the westernmost portion of the island toward the south (Figure 3). This groin field (Figure 4) consisted of seven groins built over a period of four years (1967-1970). These groins, consisting mainly of hexalegs, were constructed for the purpose of stabilizing the shore. In fact, accretion has occurred between some of the groins. An old timer, however, appeared not to be convinced. He stated that the island had shrunk in size but he apparently was thinking back to much earlier days.

The surface of the island has also been raised over the years. It has apparently been a long time practice to yearly drag gravel from the shoreline up onto the island. This serves a double purpose in that it raises the level of the island and provides a relatively flat smooth surface for drying konbu. As can be seen in Figure 4 the inner sections of some of the groins are now buried.

The most recent construction activity is intended to protect the eastern end of the island from further erosion. Begun in 1975 and completed in 1980, it consists of a 276

meter-long unit made of armor blocks. About one-third of the distance is composed of hollow triangular blocks and two-thirds of tetrapods (Figure 5).

Such protective structures are expensive. It was stated that this 276 meter long unit cost about 1.5 million yen per meter for a total of nearly \$2 million U.S. The cost in 1962-63 of the seawall and in 1967-1970 of the groins was not determined. However, when the costs of all of these protective structures are added together it works out to a very high value per family.

The economic history of the island is also interesting. As best could be determined the sole income today is from konbu. However, early in the century fishing, especially for herring, and iodine manufacturing were important. The island used to have three iodine factories, but the industry was discontinued in 1917.

Until five years ago the families were full time residents and their buildings included a school house. The island is connected to the mainland by underwater telephone, electricity, and even a freshwater supply. Buildings are relatively modern. The most common structures beside dwellings are the ten konbu drying sheds which can be distinguished by the windowed vents at their tops (Figure 6). These sheds are used to dry the konbu during inclement weather and at night. The normal method of drying is by placing the konbu on gravel pads (Figure 7), a practice common along much of the rugged coast of this part of Hokkaido.

About five years ago a major change in the use of Kojima occurred. The ten families who were residents of the island decided to move to the mainland and use the island only during the 3-4 month konbu season (June to September). Nonetheless, they maintain their structures in good condition (Figure 7).

Nearly everything on the island is geared toward harvesting and drying konbu. The ten families own an average of three konbu collecting boats per family, although the day I visited the island there were only 22 functional boats on the beach. The others were over on the mainland at Akkeshi where all but a few people had gone to participate in a fishing festival. The boats, most of which are rather new, are made of fiber glass, powered by high horsepower outboard engines, and hauled up onto the beach by cables that extend from engine sheds (Figure 8).

The island, although now only used for about four months per year, is a major base for the konbu industry. Nonetheless, it is difficult to equate the cost of island protection with present or potential income for the ten families who use the island as their base of operations. Rough calculations show that the 276 meter long armor structure placed at the base of the elongated hill between 1975-1980 cost about \$200,000 U.S. per island family!

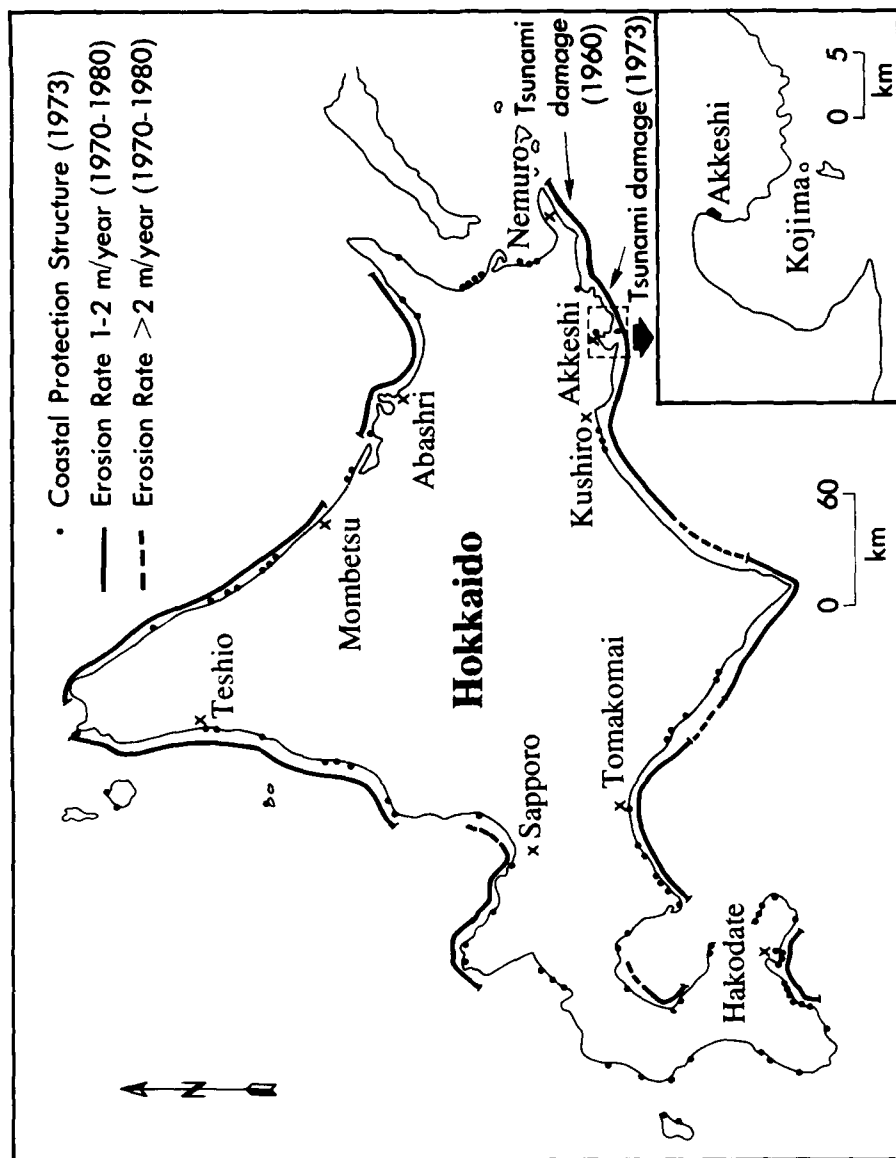


Figure 1. Hokkaido showing erosion rates, protection structure sites, and locations. Erosional data after Hokkaido Press newspaper article (9 September 1980); coastal protective works after 1974 brochure on Hokkaido coastal protection (both in Japanese).

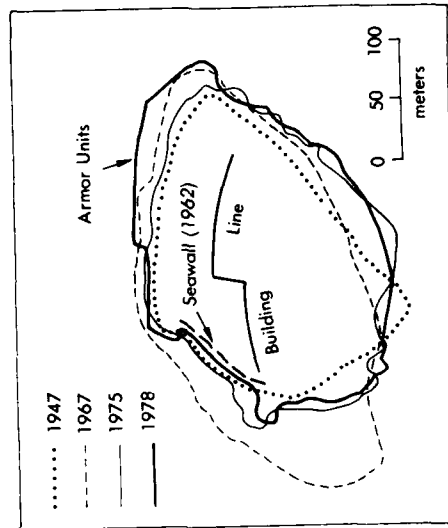


Figure 2. Changes in the shoreline of Kojima based on aerial photographs. The comparisons were made by Joann Mossa.

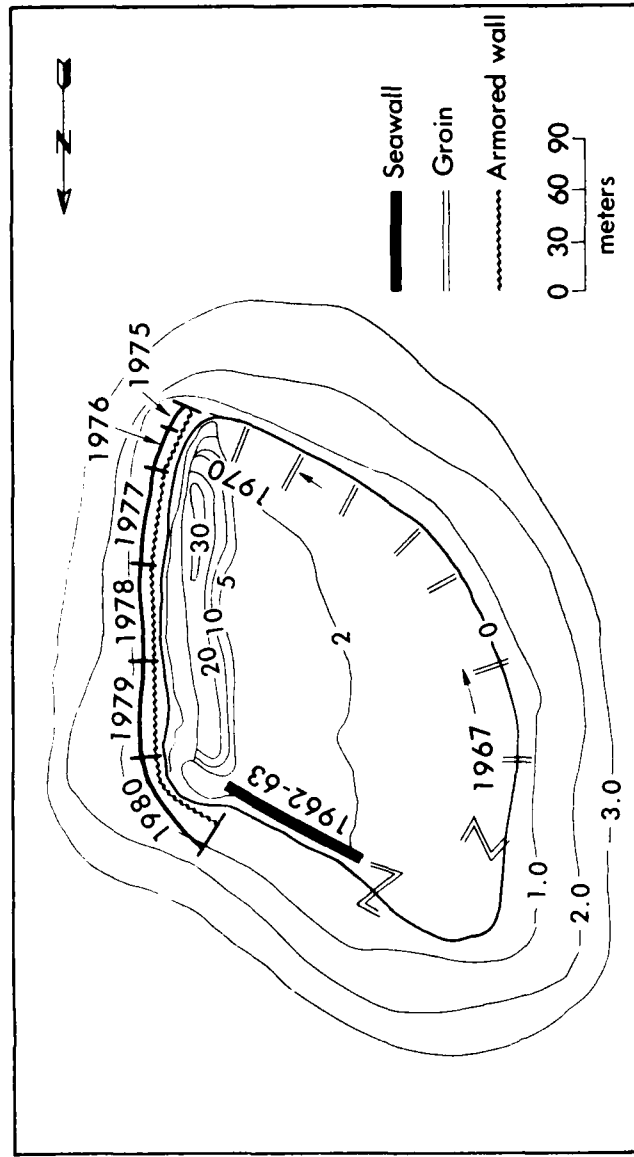


Figure 3. Defense structures on Kojima. Adapted from a map prepared by Public Works Division, Akkeshi Branch, Hokkaido.



Figure 4. A groin field on the Southwest end of Kojima. Photo taken 7/18/76, courtesy S. Taneichi.

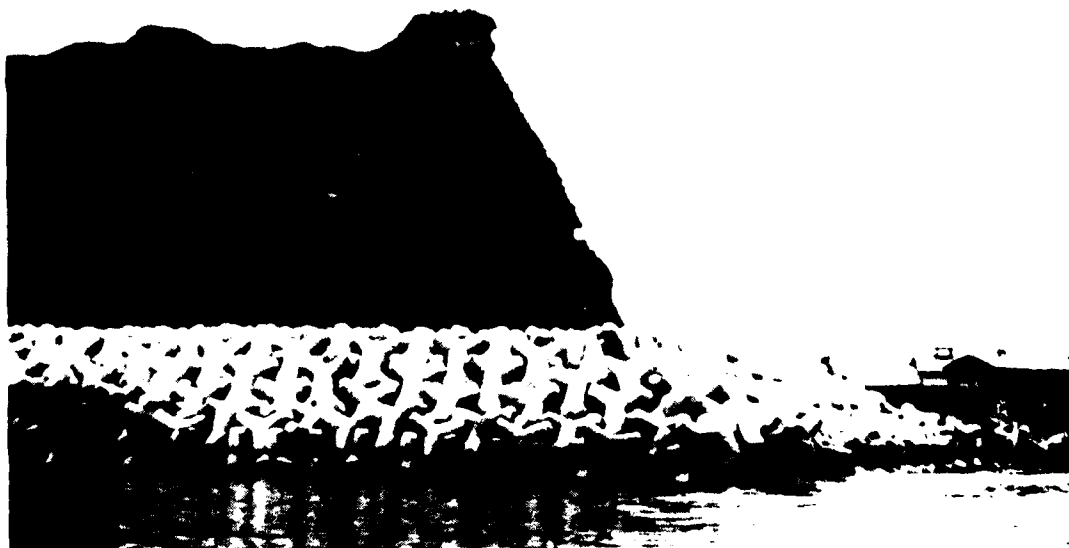


Figure 5. Tetrapod barrier along the northern end of the hill on Kojima. The formerly eroding eastern flank of the hill is visible with a protective netting in place. Photo courtesy of S. Taneichi.



Figure 6. Buildings on Kojima, looking toward the mainland. The structures with the windowed vents are konbu drying sheds. Photo taken on 7/18/76, courtesy S. Taneichi.



Figure 7. Konbu drying in front of Kojima's shrine. The vegetated (relatively stable) western flank of the hill is in the background. Photo taken 7/18/76, courtesy S. Taneichi.

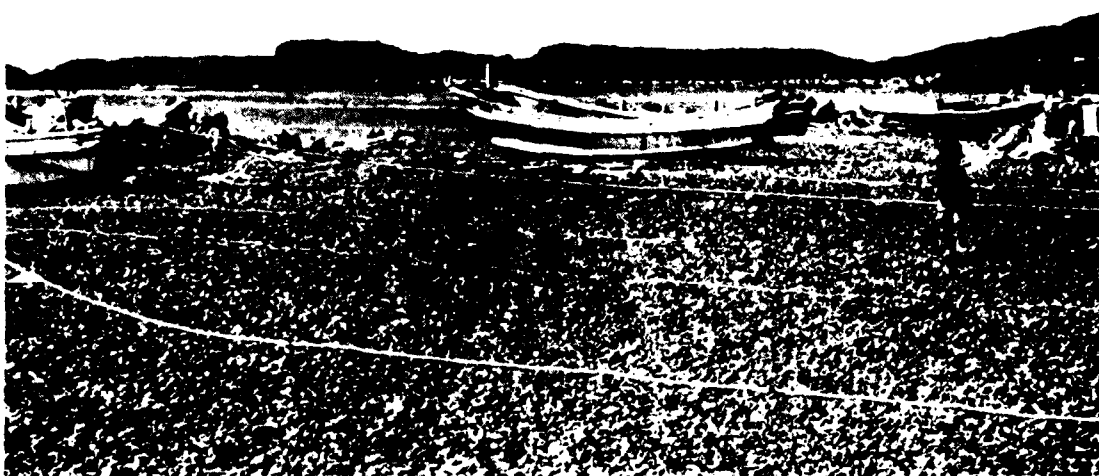


Figure 8. Boats and towing cables on Kojima. Photo taken 7/18/76, courtesy S. Taneichi.

## THE FIELD SYMPOSIUM OF THE COMMISSION ON THE COASTAL ENVIRONMENT: JAPAN, 1980

H. J. Walker and D. W. Davis

### INTRODUCTION

In 1976, the International Geographical Union (IGU) at its 23rd Congress in Moscow, USSR, established a Commission on the Coastal Environment (CCE). During the subsequent four years the Commission operated with six members representing as many countries and 112 corresponding members from 68 countries. Its four year program centered around the collection and presentation of data on five projects, namely: changes on sandy shorelines, changes on marshy shorelines, effects of artificial structures on shore processes and forms, coastal sites of scientific interest, and coastal dune systems.

During the four-year period the commission's activities were highly varied and included:

- the production of nine newsletters totaling 152 pages: these were mailed to all members and 85 others,
- the convening of regional symposia at Seattle, USA; New Orleans, USA; Nigeria; Burlington, Canada; Brest, France; Stockholm, Sweden; and Newport, USA,
- the publication of over 100 papers in various formats. Included are:
  - a. *Coasts Under Stress*, 1980, Supplementband 34, Zeitschrift für Geomorphologie, Berlin, 261 pp.
  - b. *Les Cotes Atlantiques de L'Europe*, 1979. Publications du Centre National Pour L'Exploitation des Oceans, Brest, 301 pp., and
- the publication of the "International Bibliography on Coastal Geomorphology, 1975-1978," 1980. *Komazawa Geography*, No. 16, Tokyo, pp. 68-148.

The Commission's first four years culminated in a seven-day (24-30 August 1980) field symposium that preceded the 24th IGC which was held in Tokyo, Japan. The Symposium was organized by a team of Japanese coastal experts including Drs. Tadashi Machida, Tsukuba University; Kazuyuki Koike, Komazawa University; Eiji Matsumoto, Tsukuba University; Hiroaki Ozasa, Port and Harbor Research Institute; Tsuguo Sunamura, Tsukuba University; and Nobuyuki Yonekura, Tokyo University.

The Symposium, limited to one bus load, attracted 24 non-Japanese coastal scientists from 15 countries. Australia, Brazil, Chile, Hong kong, Italy, Korea, The Netherlands, New Zealand, Singapore, Sweden, and Tunisia were represented by one each. Canada sent three participants; England, two; France, two; and the USA, six. Unfortunately, there were no representatives from the USSR or China although some coastal specialists from those countries had planned to attend.

### THE FIELD TRIP

The Narita View Hotel located near Tokyo International Airport, about 60 kilometers from Tokyo, was the starting point. The first official function was a "get acquainted" session on Sunday evening, the 24th, at which several welcoming speeches were made. On

Monday morning the group departed promptly at 0800 (a promptness that was characteristic of the entire six days).

During the three days of bus travel, the group was treated to an extremely varied set of coastal views and experiences. They ranged from the examination of marine terraces that serve as evidence of past tectonic activity to walking along shorelines that have been almost completely altered by man. Some highlights are presented below.

The first stop was at Kashima (Figure 1). About 20 years ago, Japan initiated a decentralization plan when it began to develop large harbors and adjacent industrial complexes in areas outside the Tokyo-Osaka corridor. One of the first such locations selected was at Kashima, an area of sand dunes on the Pacific Coast some 80 kilometers east north east of Tokyo. The harbor has been formed by cutting a Y-shaped waterway into the sand dunes. The harbor, which was begun in 1963, was sufficiently complete by 1972 to accommodate supertankers of the 250,000 ton class. The area also supports an iron and steel plant that will eventually produce 10 million tons per year.

South of Kashima is the Tone River, the third longest river in Japan. It, like most rivers in Japan, has been altered greatly. High artificial levees line its banks and watergates have been built to control flooding, prevent saltwater intrusion, and provide for water storage. Factories located in the Kashima industrial area utilize fresh water from the 261 million m<sup>3</sup> stored behind the Tone River watergate.

One of the most intensively studied shorelines in this part of Japan is the 60 kilometer-long Kuju-kuri Beach that lies east of the largest uplifted coastal plain in Japan. This beach is interesting for several reasons. For example, the analysis of its beach materials has shown that long-term longshore transport is from the cliffy headlands found at both ends of the beach toward its center. Not surprisingly, it has also been found that erosion is occurring at both ends of the beach and aggradation at its middle. Possibly the most impressive point gained from this location was the detail which characterizes the specific studies done by the Japanese.

Sharp contrasts within short distances are typical of the Japanese shoreline. Such is the case between Kuju-kuri Beach and the Bozo Peninsula south of Kamogawa (Figure 1). This peninsula contains some of the best examples of raised marine terraces of Holocene age in Japan. The heights of these terraces range from four to over 20 meters above present sea level. They record the history of seismic activity that has occurred along this coastal area. The lowest of the four terraces is considered to have emerged during the great earthquake of 1703. The most recent uplift of major importance (1.5 meters) in the Bozo Peninsula was during the 1923 Kanto earthquake, the earthquake that caused such great destruction in Tokyo. One of the important discoveries associated with these terraces is the fossil coral present on the upper terrace. This coral, which grew about 6000 years ago, is at the northernmost location of Holocene corals in the Western Pacific. Presently such corals are found only in more tropical locations.

On the south end of the Miura Peninsula (south of Kurihama, Figure 1) are some excellent examples of wave-cut benches. They were uplifted during the 1923 earthquake mentioned above. Some of them are composed of steeply inclined layers of tuff and mudstone. Because these deposits have different resistance to erosion, a washboard-like surface has developed. In places the local relief of these "platforms" is as much as 3 meters.

At the head of Sagami Bay is another long (40 kilometer) beach that is exposed to the

Pacific. As in the case of Kujiyukuri Beach, it has been studied in some detail. It appears that most of its sediments are derived from the river which debouch into the bay from the highland that is adjacent to and just north of the beach. Therefore, it is not surprising to find that local beach deposits are similar to those in the nearest river and the texture of beach materials is coarse, especially near river mouths.

Another earthquake prone area is the Izu Peninsula. A four hour boat trip along the southern part of the Peninsula provided a different view of the coast from that afforded during the three day bus ride to Shimoda. This coast, composed mainly of volcanic rocks of a variety of origins, provides some of the most attractive scenery in Japan. Pocket beaches with white sand (derived mainly from shell fragments) are common as are wave-eroded cliffs. Along the shoreline, landslides are fresh and conspicuous and give testimony to the frequency and recency of earthquakes. Indeed, the most recent slides were caused by strong earthquakes in 1974 and 1978.

It was just such a setting that our Japanese hosts had selected for the final days of the Symposium.

## SHIMODA

The program during the three days at Shimoda was also varied. It consisted of four paper sessions, a field excursion by foot, a tour along the Izu Peninsula shoreline by boat (described above) and enough free time to visit the town of Shimoda, the town made famous by being the port where Commodore Perry first landed in Japan. All participants were housed at the Shimoda Marine Research Center, a division of Tsukuba University. The director, Dr. H. Watanabe, and his staff were most cordial and helpful.

During the paper sessions, participants presented reports on various coastal topics. Paper session one was devoted to reports dealing with the Commission's five projects, summaries of which are presented later.

Paper session two consisted of four papers on coastal archaeology. Greece, Turkey, Tunisia, Chile, and Peru were the field areas discussed. A problem common to most of the coastal sites examined is destruction of valuable archaeological material because of sea level rise, marine erosion, and nonexistent or weak management policies. In some areas coastal sites have been buried by natural processes and by urban development.

The third paper session was devoted to ten reports on beach evolution and coastal sand dunes. Papers by participants from Italy, Brazil, Hong Kong, New Zealand, and the United States dealt with beach erosion, spit formation, and other shoreline changes. Five other papers treated coastal dunes of Korea, Japan, Sweden, and Singapore. Each speaker emphasized the dynamic changes that occur in coastal environments, e.g., those changes caused by typhoons, marine transgression, and recreational activity. It was shown that, in most cases, changes are localized and that any attempt to extrapolate for entire coastlines is unwise. It was further demonstrated that the development of a general explanation for coastal change in the Holocene will be difficult.

The last paper session dealt with coastal archaeology (five papers) and with nearshore processes in relation to the artificial modification of the shoreline (five papers). The research conducted on archaeological sites in Japan, British Columbia, Puget Sound, and Central America was discussed. All authors emphasized the difficulties inherent in coastal archaeology and expressed concern over the destruction of sites as had those who had

discussed coastal archaeology two days before.

Two of the final five papers treated nearshore process and form by examining littoral transport in Quebec and bed morphology on intertidal shoals in The Netherlands. One dealt with coastal sectors of special scientific interest. Another examined man's role in changing the coastal environment through the construction of canals in Louisiana. The final paper, appropriately, was an evaluation of the status of Japanese coastal geomorphology.

#### THE COMMISSIONS FIVE PROJECTS: SUMMARIES

- "Recent Changes on the World's Sandy Shorelines" by E. C. F. Bird, Australia, Chairman of the Commission. Sand deposition has been extensive on many parts of the world's coast since Holocene sea level rise about 6000 years ago. In some regions, deposition resulted in progradating shoreline features such as sandy barriers, beach ridges, or dune systems. Coastal plains and barriers of Holocene age occur on the Gulf and Atlantic coasts of North America, along much of the Brazilian and West African coasts, and on segments of the African, Indian, Malaysian, Indonesian, and Australian coasts.

Sand from erosion of arenaceous rocks in cliff and foreshore outcrops and that derived from hinterland sediments carried by wind and rivers, washed from coastal slopes, or deposited by littoral currents has resulted in sandy shorelines. In some cases, the sand supply is continuous, but this type of progradation is the exception. Most of the world's sandy shorelines are retreating. They are not balanced by shoreline deposition, but losing "ground" to erosion.

This contradiction to early assumptions implicit in coastal studies is the culmination of the gradual accumulation of data on the world's sandy coasts. Since the early 1950s, research activity on the historical change in sandy shorelines has shown that these coastal segments have generally been retreating over recent decades. Progradation is quite restricted and coasts exemplifying advance and retreat are characterized by little net change.

To explain the retrogradation process Bird examined the factors responsible for advancing shorelines, recognizing that the absence of these factors will promote coastal retreat. In assessing, therefore, erosion along a sandy shoreline the following factors should be considered:

- diminution of fluvial sediment yields following dam construction,
- effects of man's impacts on shorelines, notably artificial structures, beach mining, and offshore dredging,
- reduction of beach material by losses onshore, offshore, and alongshore and by attrition,
- diminution of sediment supply from decelerating cliff erosion,
- effects of coastal submergence,
- diminution of onshore sediment flow from the sea floor; and,
- possibility of increased erosion through increased storminess in coastal waters.

No single explanation will account for the modern prevalence of erosion on the world's sandy shorelines. It is not simply one factor, but a combination that differs from place to place.

- "Changes in Coastal Salt Marshes and Mangrove Swamp (Mangals) Within the Past Century" by Andre Guilcher, France, Member of the Commission. As is the case, with many topics, the initial problem encountered by Guilcher was defining salt marshes, since the term has no uniform meaning worldwide. To solve the ambiguity he chose to include in his definition the outer or seaward margin of vegetated coastal terrain, excluding *Salicornia*, but including *Spartinae* since they have "a dense network of roots and rhizomes which helps to stabilize the intertidal flat throughout the year." In tropical mangals (mangroves), the outer edge is usually easy to determine. Although some trees may be growing outside of the canopy, and therefore distinguished from the "forest," their presence may indicate whether the marsh is advancing or retreating. Using these definitions, Guilcher discovered no significant trend in the evolution of coastal salt marshes and mangrove swamps.

One major concern is the impact and shoreline change initiated by man's activities. In northwestern Europe, and the Far East, reclamation has generally reduced the extension of salt marshes, so that the "shoreline" is often completely artificial. The end result is that marshy shorelines are diminishing in area through dredge and fill operations to reclaim residential, commercial, or recreational real estate. In many regions, laws were established to prevent excessive development on the alluvial wetlands. Man has also affected mangrove swamps. In Tanzania, Mozambique, Nigeria, Gabon, Benin, India, and Bangladesh mangroves are disappearing from their coastal habitats. In these countries wood and bark exploitation and reclamation activities have destroyed the forests.

When man is not a factor, many areas appear to be stable. There is an apparent balance between progradation and retreat. Since 1935 numerous authors documented the rate of deposition and overall change that takes place in a marsh under all types of climatic conditions.

In temperate latitudes, *Spartina anglica* has had the same influence as *Avicennia* on tropical shores. Its spread resulted in a rapid extension of marshes in south England and adjacent countries during the last century. However, periods of die-back resulted in a recession of the marshes, this is especially true in England. In general, the world's marshes are not threatened by natural processes, that is, there is no evidence of widespread erosion at the seaward margins of salt marshes and mangrove swamps. The principal threat is from human interference in the natural processes.

- "Effects of Artificial Structures on Shore Processes and Forms" by H. J. Walker, U.S.A., Vice Chairman of the Commission. In order to protect the world's shoreline, man has constructed various types of artificial structures. In the process, he has become an important agent of geomorphic change. This is not surprising, since the coastal zone has always been considered a favorable site for human settlement. The dynamic nature of shore processes requires civil engineers to build structures that will protect the areas social and economic investments. This concern over defending the shoreline from the rigors of the sea is at least 4,000 years old and continues at an accelerated pace. Cost is the critical issue. Engineers can design integrated protective units to reduce or terminate land loss. Cost-benefit ratios, however, often do not justify the expense, so the structures are not fabricated and the man-made environment is threatened. If monies are available there are no guarantees that the finished structures will defeat the natural processes. There are too many variables at work in the natural system to assure success. What will happen is an alteration in those processes. Positive and negative effects can be expected depending on the processes at work and the type of artificial structure utilized.

A structure's affect on the shore environment depends not only on what type

protective unit is used, but also on its size, shape, material, durability, permeability, and flexibility. When using artificial structures for harbor development, coastal reclamation, or for the control of cliff, dune, and beach erosion, the units serve to separate land and sea. The type of structure used may be called a seawall, dike, levee, embankment, revetment, or bulkhead. In all cases, the primary purpose of the man-made implacement is to modify wave energy in order to prevent flooding and/or erosion. To accomplish this goal the interface structure alters the shore by: (1) reflecting wave energy leading to beach removal and provide steepening, (2) increasing the flow rate of littoral currents, (3) eliminating cliffs as source regions leading to downdrift beach starvation, (4) preventing the exchange of sand between beach and dune, and (5) concentrating wave energy at the ends of structures leading to increased erosion.

Seawalls and other land/sea protective structures are placed parallel to the shoreline. Engineers also use groins, jetties, and other structures that are designed to intersect the shore at an angle. The purpose of these nonparallel structures is to trap drift and retard shore erosion, or to prevent littoral drift from entering a channel thus reducing its usefulness. Morphologically the structures tend to lengthen and compartmentalize the shoreline. Like seawalls, they reflect and concentrate wave energy, alter littoral currents, and reduce the sediment supply from cliffs. They also trap littoral drift. The captured sediments result in downdrift erosion, since their movement is retarded by the groin or jetty.

To protect harbors, breakwaters are built. These armor units may be made of a variety of materials. Along a high energy coast, concrete, rubble, and steel are preferred. Floating tires, fluid, and artificial seaweed breakwaters are used in low energy systems. Due to the variety of structures and variations in positioning on the coast, the units do alter significantly natural processes in the same way as the other shoreline protective units.

Most of the world's 450,000 kilometer-long coast has not been modified by man. However, in those coastal areas with high population density, there has often been a concentrated effort to change the natural system. In such areas artificial structures have affected the movement of shoreline material, altered natural processes, and resulted in a new shoreline form.

- "Worldwide Coastal Sites of Special Scientific Interest" by M. L. Schwartz, U.S.A., Corresponding Member of the Commission. This paper is a synthesis of selected data concerning the protective legislation, published literature, and site location of coastal sites of special scientific interest around the world. The sites include: geologically important cliffed coasts, geomorphically unique coasts, sectors of special biological interest, and valuable, yet endangered, archaeological sites. In a few coastal regions such sites are recognized and adequately regulated, but this is the exception. Most coastal countries are unaware of the scientific significance of coastal sites and, therefore, show little concern in their protection.

Two forms of bias entered into the compilation of the report. First, the data used was mainly that received from the Commission's corresponding members and was not derived from an exhaustive search of the literature. Second, the authors interest in geoarchaeology led to an overabundance of information on this particular subject. Nevertheless, the report represents one of the few attempts at cataloguing the world's sites of special scientific interest.

New Zealand, Australia, Europe, and the United States are presented as having a history of laws that protect and preserve all types of scientifically important sites. What

has been regarded as good practice in these regions must, in some cases, be restructured to include six important elements. A framework for the designation and protection of coastal sites needs to include therefore: (1) the identification of sites on the basis of field, literature, and remote surveys, (2) description of each site's characteristics and dynamics based upon analysis of ecological relationships and littoral sediment budgets, (3) comparison and evaluation of individual sites on the basis of scientific information, (4) formulation and implementation of appropriate legal measures for the designation, ownership, and protection of sites, (5) development of management strategies supported by legal and economic measures, and (6) the identification and development of international management strategies to consider the biological and geomorphological systems that cross political boundaries. Most countries have few, if any, of these mechanisms for protecting their valuable coastal sites.

At present, interdisciplinary studies by coastal specialists are increasing. The knowledge obtained from these cooperative efforts reveals the need to collect and coordinate information on a worldwide scale, develop procedural recommendations, and disseminate research results to the human and geo-scientists. In the final analysis, coastal sites of special scientific interest can only be protected through legislation. It is, however, up to archaeology, geology, and geography to identify the sites. The marriage of these disciplines will result in a complete analysis from site location through its geomorphology, stratigraphy, and sedimentology to, where appropriate, a geochronological model of the dynamic relationships between man and the land. This technique can aid considerably the decision making vis-a-vis legislative process.

- "Coastal Dune Systems" by J. O. Norrman, Sweden, Member of the Commission. Eolian processes and development of coastal dune systems are documented in a number of field and laboratory studies. Since the 1500s, man's impact on coastal dunes can be found in the historical record and from field evidence. Not all phases of dune destruction are, however, attributable to man. The most critical element in dune nourishment is the feeding mechanism from the narrow changing beach zone. The response varies in the long and short term. In the geological time scale, there is an immediate dune reaction to a sand deficit. In the short period, the changes are difficult to distinguish and assess as to whether they represent a normal short term occurrence or a definite trend in a long-term developmental sequence.

Research on coastal dunes can best be summarized by sorting the work into five categories: (1) experimental quantitative research on transportation and sorting by wind action, (2) reconnaissance studies of dune characteristics and development, (3) inventories of coastal dunes for environmental assessment and management planning, (4) management techniques and planning, and (5) effects of management on natural development.

The first category covers a rather vast field from small-scale laboratory studies to monitoring systems of dune advance in natural environments. From these studies and observations it is possible to identify the factors influencing morphology, structure, and texture of depositional forms. In a dune field, wind velocity is not the principal variable; surface roughness and ground moisture determine dune morphology. In humid periods, deflation relief dominates, whereas in dry periods, depositional micro- and meso-forms develop. Ripple mark size tends to be proportional to the average grain size and inversely proportional to the degree of sorting. Unfortunately, vital information regarding dune shape and size, textural characteristics such as grain size, sorting, and bulk density, period of observation, and wind statistics is often incompletely presented. This makes it difficult or impossible to synthesize the data into more general trends.

Environmental assessment and management planning inventories of coastal dunes has in the last 20 years become evident to planners. Most countries recognize the need to resolve the conflicts between the exploitation of dunes and the preservation of them as a natural resource. To resolve this conflict many countries have established special commissions to identify, evaluate, and plan recreational activities. These planning authorities recognize the principal problems in coastal dune areas and try to control land use either to prevent erosion or to restore already damaged areas.

Coastal dune management techniques deal with preventing erosion, supplying and collecting sand to reestablish eroded dunes, stabilizing eroding and reestablished dunes, and formulating guidelines for building, transportation, recreation, and other man-related activities. In principle, most techniques are quite old and involve fencing or planting a ground cover to stabilize the dunes. Through time the practices have remained basically the same.

During the centuries when stabilization of wind-blow sand mainly concerned old, previously vegetated dune areas, management perspective was entirely utilitarian. Today, coastal management in most cases deals with problems concerning the dynamic system of active dunes directly connected to the beach environment.

#### CONTRIBUTED AND INVITED PAPERS: SUMMARIES

##### Coastal Archaeology

John Kraft, University of Delaware, U.S.A., reported on "Late Holocene coastal changes and resultant destruction or burial of archaeological sites in Greece and Turkey." His fieldwork indicates that shorelines incised into Neocene silts and Quaternary sediments are eroding and that the rate of retreat is a function of the geomorphic setting and exposure to wave activity. Some Mid-Helladic sites are disappearing because of the cliff retreat that has accompanied a rise in sea level. A sixth century chapel, Roman wall and pottery dump, and several line kilns have fallen prey to the sea. Similar erosion and destruction is recurring along many reaches of the Greek and Turkish coast. In some of the region's active floodplain-delta areas cultural resources are being buried. Such sites are being discovered by using a geology/archaeology approach. Nevertheless, the number of buried sites scattered across the alluvial plains is largely unknown.

Similar problems were noted for North Africa by Roland Paskoff, University of Tunis, Tunisia, in a paper on "Marine erosion on archaeological sites along the Tunisian coast." He revealed that 23 of the 45 sites investigated are threatened by marine erosion. Most sites date to the Punic and Roman periods. Eight are undergoing severe erosion, all are moderately affected, three are experiencing a small erosional problem, and 21 are not affected.

Alan Craig, Florida Atlantic University, U.S.A. in discussing the "Coastal sites in northern Chile," reported that a number of factors are threatening a number of famous archaeological sites. He noted that Chile's hyperarid conditions in the Holocene has limited the availability of favorable habitation sites. Settlements tend to be aligned along those intermittent or perennial streams that reach the Pacific. It appears that occupation of such settlement was continuous with one superimposed on another through settlement succession. The end result is that most major sites are endangered by present-day urbanization, and road construction. Looting, to satisfy the market demands for artifacts, is also a major factor. Although laws exist to protect these sites, they are not enforced.

Local estimates indicate that no more than 30 percent of the material remaining in these sites is undisturbed. In some cases, the site has been completely destroyed.

On another sector of the South American coasts, Jose Araya Vergara, University of Chile, reported on former sea level sites that are now as much as 20 meters above sea level. His paper "Postglacial evolution and human settlements in the southern beach ridges of South America," showed how the geomorphological position of these archaeological sites can be utilized to document sea level change.

Two papers were presented on Japan. Yoshinori Yasuda, Hiroshima University, Japan, in "Man and his late Holocene coastal environment in Central Japan," explained the use of pollen, diatoms, and plant remains to document man-land relationships. By utilizing these techniques, the palaeo-geographical sequence of environmental change was assessed. William Hurley, University of Toronto, Canada, was concerned with the question "Why aren't there more sites on the Pacific coast of the Oshima Peninsula, southeastern Hokkaido, Japan"? Prehistoric research in the area is hampered by sea level changes, volcanic eruptions, urban sprawl, and intensive land use in areas adjacent to the coast which have hidden or destroyed many sites. Roy Carlson, Simon Fraser University, Canada, reported in his paper "Problems in archaeological site protection on the coast of British Columbia," that regional governments need workable management policies for archaeological sites. Sites are there, but damage is on-going and difficulties in site protection are manifold. Site recognition, ownership, and other problems were discussed. Each case appears to require a different management policy.

Maurice Schwartz, Western Washington University, U.S.A., read a paper entitled "Puget Sound coastal-archaeological sites revisited: review, up-date, legislation." After presenting information about the cases in the Puget Sound region, he noted that the goal is to gain a better understanding of pre-Salish occupation. However, to accomplish this task, these five sites and others must be protected. Protective legislation does exist and has been used to save some sites. Schwartz believes that the lessons learned in Washington may be used in other coastal areas where sites are endangered.

D. R. Stoddard, Cambridge University, England, pointed out in his paper "Destruction of Maya remains by shoreline erosion, Belize sand cays, Central American," that sand cays are subject to constant change. Some have disappeared in the last 150 years. Of course, when the cay is changed or eliminated, the Mayan artifacts are destroyed. The beach-crest sites are ephemeral in nature and can hardly be protected from further erosion. They represent a diminishing archaeological resource; a resource that is important as time-markers in the geomorphic evolution of the cays.

Although the paper by Vincent May, Dorset Institute of Higher Education, England, on "Coastal sectors of special scientific importance in Europe: existing designation methods, present site status, and proposal for future protection," is not strictly archaeological; it is relevant and therefore is summarized here. May was concerned about established systems of legislation for the designation and management of coastal sites. He was able to identify 355 sites of special scientific importance in Europe. More than 75 percent are in France and England where legislative policy is well established. The seven other countries (Belgium, Bulgaria, Denmark, Greece, Netherlands, Portugal, and Norway) discussed have highly variable policies as to what should be protected. May's printed report lists sites that are regarded as meriting future protection.

## Beach Evolution and Coastal Sand Dunes

Paolo Fabbri, University of Bologna, Italy, in the paper "Methods of forecasting beach erosion through investigation of historical data," discussed the integration of the traditional geomorphic-mathematical techniques of coastal analysis with an investigation of historical records. Old maps, reports, and documents can be utilized to show coastal evolutionary patterns. In Italy, historical documentation of man's use of the coast is quite good. Some cartographic materials date from the 16th century. Applying this technique to the Po delta area has revealed that during the last 25 centuries the shore advanced from one to ten kilometers.

This discussion about a stressed deltaic environment in Italy was followed by a paper on "Accelerated spit bar formation in the Caraguatatuba Bay, state of Sao Paulo, Brazil," by Olga Cruz, University of Sao Paulo, Brazil. Cruz along with two colleagues have monitored the dynamics of a spit through fieldwork and air photo analysis since 1962. Their cartographic and sedimentologic research established anthropic influences introduced by piers recently constructed in the Bay.

Antony Orme, University of California, Los Angeles, U.S.A. reported on "Flandrian shoreline changes in California." He utilized the integrated techniques emphasized by Fabbri. Between 15,000 and 8,000 years BP sea level rose at a rate of 2 centimeter/year. The rate declined from 8,000 to 6,000 years BP and since that time has been between 0.1 and 0.2 centimeter/years. Orme notes that there are differences in rates between northern and southern California, but that in both areas both vertical and horizontal changes are evident. Erosion and deposition are both important in California. However, in general terms California is gaining more land than it is losing.

Chak Lam So, University of Hong Kong, Hong Kong, provided a paper entitled "Beach changes in a typhoonal environment: The Hong Kong experience." His field monitoring has shown that Hong Kong is losing valuable beach material, that the beach recovery process is slow, and that recovery tends to be curtailed by successive typhoons. The state of a beach at any time is, therefore, determined by the degree of its recovery since the last typhoon.

Whereas So's Hong Kong experience focused on one problem, Roger Mclean, University of Auckland, New Zealand, in his paper, "Perspectives on recent changes in New Zealand," was concerned with large-scale progradation and retrogradation. In late Holocene time, deposition of large quantities of sand and gravel were responsible for a net progradation of up to ten kilometers in some locations. Along other parts of the New Zealand coast, however, substantial shoreline recession has occurred. Whereas the general patterns of progradation and retrogradation are relatively easy to explain, recent trends in coastal change are less easily understood. Present-day physical and human variety along the coast inhibits the development of any general explanation. It is mainly a problem of scale.

The first paper about sand dunes was entitled "Coastal sand dunes of the western coast of Korea," and given by Dung Won Park, Seoul National University, Korea. Park reported that in his study area coastal dunes develop on spits, old beach ridges, and intertidal flats. The sand supply is mainly from the intertidal flats exposed to wind erosion during low tide. Airborne sediments are deposited as parabolic or barchan dunes. In the dune complex, reddish, old dunes are about eight meters higher than the present mean high tide level. Analysis of these older dunes indicates that during the past 5000 years there were at least three periods when the coastal dunes ceased growing and were vegetated.

Kunihiko Endo, Nihon University, Japan, noted in his paper "Coastal sand dunes in

Japan," that large-scale coastal dunes are distributed along those coasts of alluvial plains where strong westerly winds are prevalent in winter and early spring. They are especially common along the west coast of Hokkaido, and along the north and west coasts of both Honshu and Kyushu. The "Coastal dunes of Sweden," by John Norrman, University of Uppsala, Sweden, shows that the distribution of dunes in Sweden strongly correlates with the distribution of glacio-fluvial sand and with postglacial shore displacement. In fact, some dune fields are present along the highest postglacial coast line, which, in some cases is as much as 200 meters above present sea level. They are also present along the coast where current uplift is 0.8-0.9 meters/century. The main source of dune material is the reworked glacio-fluvial material that is exposed by rebound.

Nobuyuki Yonekura, University of Tokyo, Japan in the paper "Geomorphic features of the Pacific coast of central Japan," summarized coastal evolutionary trends in recent times. Like Orme and McLean, Yonekura noted the variability from place to place based on the regional geologic and geomorphic conditions. He emphasized the importance of tectonic movement in Japan's coastal evolution. A four category classification scheme was used to illustrate the coastal region's variability. Type one, characterized by the development of deltaic plains, is found near major metropolitan areas. Type two, is backed by high mountains whose streams provide large quantities of alluvium. Therefore, any artificial structures along such coasts will interrupt the orderly movement of sediments and bring about large geomorphic changes. Type three represents Japan's peninsulas which are fringed by rocky coasts and pocket beaches. In type three, natural change is expected to be small. Type four includes smooth, sandy beaches facing the open sea where migrating sand dunes and beach erosion are major problems.

P. P. Wong, University of Singapore, Singapore, discussed "Beach evolution between headland breakwaters." Along the southeast coast of Singapore there are a series of more than 50 breakwaters that protect 12 kilometers of reclaimed land. Both riprap and gabion breakwaters have been used. Major variations in beaches between the breakwaters depend on the quantity of sand available. However, within each beach type, evolutionary processes are dependent on low wave energy, littoral drift, and the absence of a persistent wave direction.

#### Nearshore Processes and Artificial Modification

Jean-Marie Dubois, Universite de Sherbrooke, Canada, reported on the "Evolution historique du littoral de la cote nord du Saint-Laurent, Quebec, Canada."

His work focused on the origin and movement of sediments along the north coast of the St. Lawrence. By examining historical maps and air photos he assessed changes in this coastline.

"Bedforms on intertidal shoals," was the title of the paper presented by Joost Terwindt, University of Utrecht, The Netherlands. The shoals he studied exhibit a variety of bedforms including ripples, megaripples, and sandwaves. These forms are generated by, and their dimensions are related to, the intensity of the tidal currents. Detailed measurements were conducted on two different bedform types, and it was discovered that the bedforms are active only around spring tide and are nearly immobile during neap tide.

The paper by Donald Davis, Nicholls State University, U.S.A. was entitled "Louisiana's canals, reclamation and coastal change." It documented the problems associated with canalization in the United States' largest expanse of wetlands. Canals associated with

drainage and reclamation, transportation, trapping, logging, petroleum exploration development have created a patterned landscape. Louisiana's 3.2 million miles of m are eroding at a rate of 43 km<sup>2</sup> annually-more than 25 percent is attributed to canalizat

Kazuyuki Koike, University of Komazawa, Japan, closed the three-day paper session by presenting his paper "Present status of Japanese studies in coastal geomorphology." Koike reported that Japan's coastline is about 32,000 kilometers long including the small islands. About 85 percent of that coastline, associated with Japan's four major islands, is classified as a cliffy coast. Large-scale coastal sand dunes are also developed on alluvial plains. The coastal lowlands are so densely populated that they are now called "man-made." In fact, more than 90 percent of Japan's coast in the highly urbanized areas (around Tokyo, Osaka, and Nagoya, for example) has been altered by man.

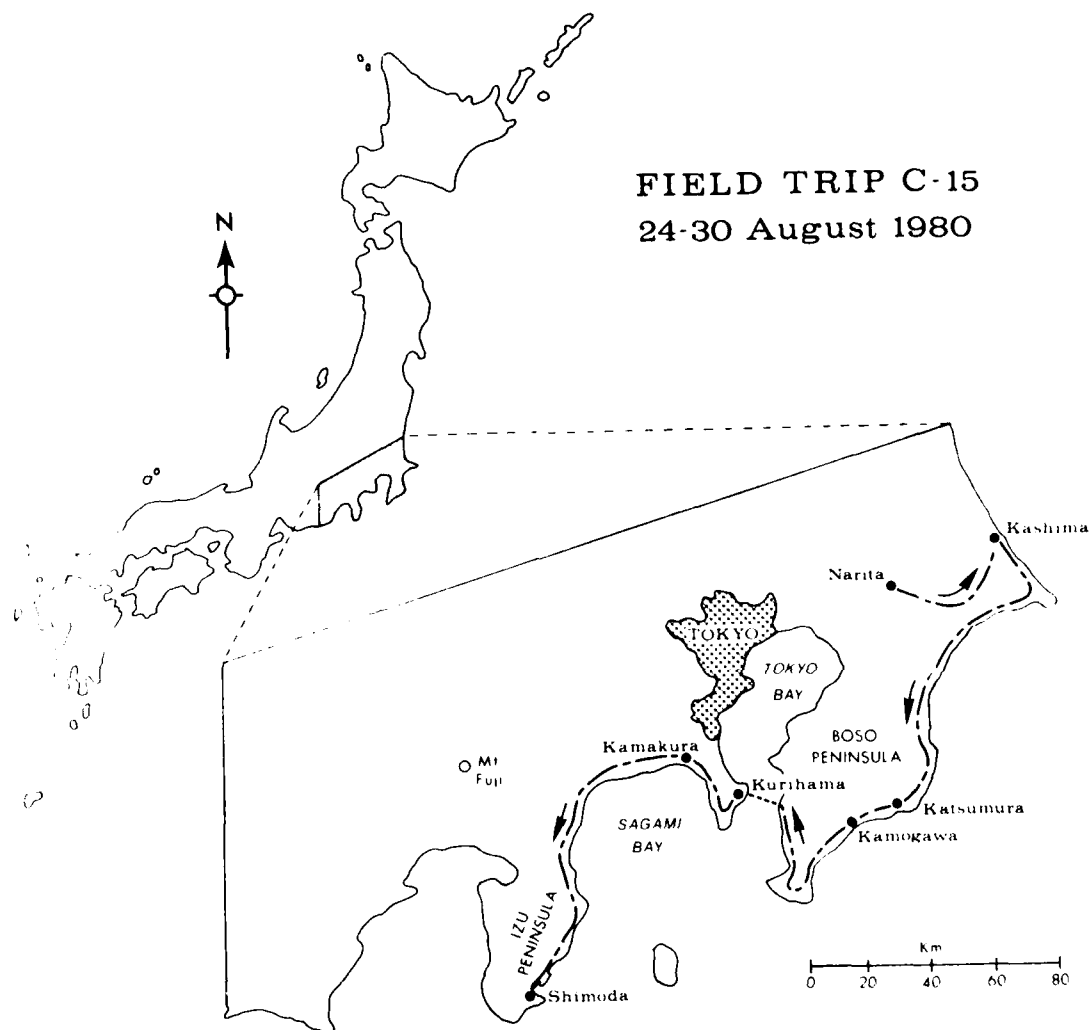
### CONCLUSIONS

Both the field and paper sessions of the Symposium were very beneficial. Japanese had planned well and the materials provided (field guides, special reports, participant abstracts from which much of the material in the summaries presented at the Symposium were taken) were, and are, extremely beneficial. The Symposium, which served as an excellent introduction to the field four years of Commission activities, may well be considered an excellent beginning for the next four years.

The five project reports are to be published as a special issue of *Komazawa Geographical Papers* and the archaeological papers have been issued as a proceedings volume. For information about the former, please write K. Koike, Department of Geography, Komazawa University, 1-23-1 Komazawa Setagaya-ku, Tokyo 154, Japan. For copies of the latter, contact M. Schwartz, Department of Geology, Western Washington University, Bellingham, Washington, 98225, U.S.A.

If further information about IGU's Commission on the Coastal Environment is desired, please contact either E.C.F. Bird (Chairman of the Commission), Department of Geography, University of Melbourne, Parkville, Victoria, 3025, Australia, or H. J. Walton (Vice Chairman of the Commission), Department of Geography, Louisiana State University, Baton Rouge, Louisiana, 70803, U.S.A.

Figure 1. The route of the field trip of the Commission on the Coastal Environment along the Pacific Coast of Japan and some of the locations visited.



## GASEOUS ELECTRONICS RESEARCH IN AUSTRALIA

Leon H. Fisher

### INTRODUCTION

Gaseous electronics has an old and honorable history in Australia with its roots in the Oxford laboratory of J. S. Townsend. The most recent manifestation of the present vitality of the field in Australia was demonstrated by the inauguration in February 1980 of an annual meeting on the subject (see Appendix I). Perhaps in no other country has there been so much research in gaseous electronics per capita of total population as in Australia.

Gaseous electronics research started in Australia in the mid-twenties with V. A. Bailey at the University of Sydney, although no trace of this work is to be found on the campus today. Despite my inquiries, no one that I asked knew anything about Bailey's history except what I had already known, that he had been a student of J. S. Townsend at Oxford and published papers with Townsend between 1921 and 1923. He subsequently joined the Physics Department of the University of Sydney where he carried out extensive measurements of electron and ion mobilities, electron and ion diffusion coefficients, and electron attachment probabilities to form negative ions. The methods used were largely those of Townsend or an extension of the methods of Townsend. From transport coefficients, it is possible to infer values of the electron-atom/molecule collision frequencies as well as other fundamental electron-atom/molecule interactions. Aside from the general interest in determining transport properties, Bailey was also interested in radio propagation where electron-molecule collision frequencies are needed to explain cross modulation in radio waves (Luxemburg effect). This is, at present, a relatively unimportant use of such data. Today, various cross sections of electrons interacting with atoms/molecules and ions interacting with atoms/molecules are needed in a large number of applications including gas lasers, ionospheric phenomena, laser fusion, etc.

The tradition of gaseous electronics in Australia was reinforced by L. G. H. Huxley, who is primarily a theoretical physicist, first at the University of Adelaide, and then at the Australian National University (ANU). Huxley, whose influence in gaseous electronics is still felt in Australia, was born in England, but was raised from early childhood in Tasmania. He was a Rhodes scholar in 1923. Some half dozen years later he carried out research with Townsend at Oxford. After a number of appointments both in Australia and England, he was appointed in 1949 to the Elder Chair of Physics at the University of Adelaide where he built a strong group in low energy electron swarms very closely following the work of Townsend at Oxford and Bailey at Sydney. Like Bailey, he was also interested in the use of such data in radio propagation. In 1960, Huxley became the first Vice Chancellor of ANU and brought the gaseous electronics activity at Adelaide to ANU including R. W. Crompton, an experimentalist, to head the work. Crompton continues at ANU as one of the outstanding workers in gaseous electronics with an international reputation. Huxley retired in 1967; since retiring, he has coauthored a book on gaseous electronics with Crompton.

J. M. Somerville, a much beloved figure in Australian physics, worked actively on arcs at the University of New England in Armidale until his untimely death in the late 1950s. This gentle figure is still being mourned in Australia. He was succeeded by S. C. Haydon who now heads an extremely active gaseous electronics group at Armidale. The study of arcs is being vigorously pursued in the Department of Electrical Engineering at the University of Sydney.

As a further measure of the prominence of Australia in gaseous electronics, both past and present, one may also mention the following landmark publications:

- "The Behaviour of Slow Electrons in Gases," R. H. Healey and J. W. Reed (1940). This book was written by two students of V. A. Bailey. At the time of publication, both authors were employed by the Amalgamated Wireless Valve Company of Australia. The book was an excellent, and then up to date, account of measurements of electron diffusion and mobility as developed by Townsend at Oxford and by Bailey at Sydney, as well as of the diffusion method of determining electron attachment. A brief survey was also given of the use of shutter methods in measuring electron mobility and electron attachment as well. The methods described for using the data to obtain electron-atom interaction parameters have now been largely superseded.

- "The Electric Arc," J. M. Somerville (1959).

- "The Motions of Slow Electrons in Gases," L. G. H. Huxley and R. W. Crompton (1962) is a chapter in "Atomic and Molecular Processes," edited by D. R. Bates.

- "An Introduction to Discharge and Plasma Physics," S. C. Haydon, editor (1963), (this is a 509 page book of proceedings of a Summer School),

- "The Diffusion and Drift of Electrons in Gases," L. G. H. Huxley and R. W. Crompton (1974). This book is an extensive treatment of electrons in gases in electric fields where the fields are too low to produce ionization.

The present report covers gaseous electronics research activities at ANU, the University of New England, and the Flinders University of South Australia. This report is not to be considered exhaustive or complete. Other work in gaseous electronics in Australia not covered in this report consists of the extensive arc studies in the Department of Electrical Engineering of the University of Sydney (J. J. Lowke [now director of the CSIRO Division of Applied Physics], H. K. Messerle, S. Ramakrishnan, and A. D. Stokes) and studies of microwave discharges being carried out in the Department of Physics at the University of Queensland (R. W. Parsons). I visited the arc laboratory at the University of Sydney and this work will be described in a later report.

#### GASEOUS ELECTRONICS RESEARCH AT THE AUSTRALIAN NATIONAL UNIVERSITY

A description of ANU with special emphasis on science is given in Appendix II.

Gaseous electronics research at ANU is carried out by, and is the sole activity of, the Electron and Ion Diffusion Unit (often shortened to Ion Diffusion Unit) of the Research School of Physical Sciences of the Institute for Advanced Studies. The work includes all aspects of precision low energy swarm experiments involving electrons and ions including measurements of electron and ion mobilities, measurements of the coefficient of diffusion (free, not ambipolar) of electrons and ions, measurements of the ratio of the coefficient of diffusion to mobility of electrons (especially) and ions, and electron attachment coefficients. The Unit is also concerned with the theoretical interpretations of these results.

For years, the Unit was funded as a line budget item by the Australian federal government. In common with other departments and units, no proposals for research funds

need be written. This stability of funding has given an unusual degree of cohesiveness to the Unit. It has its own technical staff with four full-time technicians, and its own well-equipped shops. The head of the technical staff has been with the Unit for 27 years. The Unit has had years and years to develop facilities and techniques. The laboratory work at ANU requires extremely accurate machining of parts, measurement of electrode separations, measurements of pressures, and elimination of contact potentials. Meetings of the Unit are held every Monday and include technicians; written records of these meetings go back for 20 years.

The Unit at present has two tenured staff members, R. W. Crompton, Professorial Fellow and Head of the Unit, and M. T. Elford, Senior Fellow. Both received their Ph. D. degrees from the University of Adelaide. At the time of my visit, the Unit included the following people as well:

- L. T. Sin Fai Lam, Research Fellow, who received his Ph. D. from the University of Durham, and who worked on scattering theory with R. Nesbet at I. B. M.,
- D. J. Evans, Research Fellow, a theorist who received his Ph.D. from ANU (he was in the U. S. as a Fulbright Fellow at the National Bureau of Standards, Boulder, Colorado, at the time of my visit),
- G. N. Haddad, Research Fellow, an experimentalist who received his Ph. D. from Adelaide, and
- David Cartwright from Los Alamos who had just arrived and was to provide theoretical support for four months.

Other workers who had been with the Unit recently, but who had left include:

- R. Hegerberg, Post Doctoral Fellow, from Norway who spent two years at ANU,
- T. F. O'Malley, a theoretical physicist from the U.S.,
- D. W. Walker, Visiting Fellow, an Australian theoretical physicist,
- H. R. Skullerud of Trondheim, Norway, and
- H. Helm formerly from the University of Innsbruck, and now at SRI International in Menlo Park, California.

Up to the 1950s, the kinds of electron swarm experiments described in Healey and Reed's book were analyzed to give two parameters, the electron mean free path and the loss of energy of an electron in an electron-atom/molecule collision. This procedure was initiated early in the century by Townsend, and yielded electron-atom/molecule cross sections averaged over the electron energy distribution. The mean free path was given as a function of a mean electron energy or as a function of a mean velocity rather than as a function of electron energy. The ratio of electric field strength to gas pressure corrected to some standard temperature ( $E/p$ ) or atom/molecule number density ( $E/N$ ) was translated into a mean electron energy. Swarm experiments are indispensable in giving electron-atom/molecule cross sections at energies of less than a few electron volts where beam type experiments are difficult or impossible because of space charge and contact potential effects. They are also important in determining ion-atom/molecule interactions. Swarm experiments, however, are only capable of yielding total cross sections.

The above method of analysis of electron swarm data has now been superseded in that the Boltzmann equation is now used to obtain cross sections as a function of energy from swarm data. Phelps in the U. S. has been a leader in the use of the Boltzmann equation to obtain such cross sections as a function of energy from electron swarm data transport coefficients, i.e., electron mobilities, electron diffusion coefficients, or ratio of electron mobilities to electron diffusion coefficients in the presence of inelastic scattering. The procedure essentially involves finding the cross sections as a function of energy which when inserted into the two term expansion of the Boltzmann equation gives the observed transport coefficients. This program is being worked on energetically at ANU as well.

In situations where the Davydov energy distribution function applies (monatomic gases below the excitation potentials), one needs only one transport coefficient to evaluate the elastic scattering momentum transfer cross section. But if one has both elastic and inelastic scattering, one needs more than one transport coefficient. The ANU Unit has taken over and used Phelps' program for solving the Boltzmann equation (two term solution) for molecular gases. However, the program for the elastic scattering case had been developed independently at Canberra. In the case of molecular gases, one needs to take into account all excitation processes including rotation and vibration, and in some instances ionization as well. The presence of electron attachment further complicates the analysis.

One of the great problems in this procedure in general is the problem of uniqueness, since cross sections as a function of energy are adjusted until they reproduce the observed transport coefficients and perhaps more than one set of cross sections as a function of energy would give the observed transport coefficients. In principle, the uniqueness problem does not exist in the elastic case, but as a practical matter, it does exist in the region of the Ramsauer minimum in noble gases. The problem of uniqueness is reduced when rate coefficients for specific excitation processes (corresponding to the already available first Townsend ionization coefficients) are available.

To give an example of how the ANU Unit has attacked the problem of uniqueness, one can discuss their experimental study of electron diffusion and drift in pure parahydrogen at low enough gas temperatures such that only one rotational state in the gas is significantly populated. If the experiments are carried out at 77 K, the thermal swarm has an average energy of about ten millivolts. The rotational transition from  $J = 0$  to  $J = 2$  is about 43 millivolts, and the vibrational transition is 0.5 volts. At 77 K, the tail of the thermal electron energy distribution just starts producing transitions from  $J = 0$  to  $J = 2$ . At 77 K, 99.5% of the molecules are in the  $J = 0$  state and only 0.5% are in the  $J = 2$  state with no molecules in  $J = 1, 3, 5, \dots$  states. Thus one can neglect the molecules initially in the  $J = 2$  and higher states. If one starts taking measurements with the value of  $E/N$  very close to zero, one has elastic scattering and some rotational transitions. With increasing values of  $E/N$ , one obtains a larger number of rotational transitions and so one can look at primarily elastic and rotational transitions, and in this case one has no problem with uniqueness in analyzing the data. Parahydrogen rather than orthohydrogen was picked for this experiment because of its greater ease in preparation and the Unit would like to repeat the experiment with orthohydrogen. With normal hydrogen at 77 K, one has two or three cross sections as a function of energy to adjust in carrying out the analysis. In principle, one is able to deduce the parameters of orthohydrogen from observations in both parahydrogen and in normal hydrogen and this has been done. One has to have high purity in carrying out such experiments, and gases such as nitrogen must be eliminated. The elimination of molecular gases in the study of monatomic gases is also a great problem.

Electron mobilities are being measured by the Bradbury and Nielsen shutter method. The ANU workers think that their experimental values of electron mobilities are accurate

to 1%, conservatively speaking. Their length measurements are accurate to 0.05%, pressure measurements to 0.1%, and temperatures to 0.1%. The diffusion correction is often about 0.25% or less and the location of the position of the peak frequency for maximum transmission of electrons is about 0.1%. Pressure measurements are made with a Texas Instrument quartz spiral manometer. The application of the shutter method to obtain electron mobilities in the presence of attachment leads to some difficulties. Because of the dependence of three body attachment on the square of the pressure, the experiments in such gases are carried out at very low pressure in very long apparatus so that an appreciable number of electrons will not attach.

Diffusion coefficients and attachment rates have been measured for thermal electrons in a variety of gases and gas mixtures using the Cavalleri density sampling technique developed in 1969. This method as used at ANU consists of irradiating the gas in a cylindrical chamber by a flash of X-rays. In the absence of attachment, electrons so formed diffuse, and the time constant of decay of the electrons brought about by diffusion to the walls is measured by applying an r.f. field of about 1  $\mu$ sec duration and observing the resulting light output, which is proportional to the number of remaining electrons. Electrons, which are rapidly thermalized, may be kept at an elevated temperature by heating the gas. (Alternatively an r.f. field is used to heat the electrons.) In the case of attaching gases, electron loss involves attachment of electrons as well as diffusion. The X-ray flash lasts for 5  $\mu$ s and yields  $10^3$  to  $10^4$  electron/ion pairs. This is so low that the diffusion is free and not ambipolar. Measurements of the coefficient of diffusion for thermal electrons from this method and measurements of electron mobilities check well with measurements of the ratio of the coefficient of electron diffusion to electron mobility. Experiments using A with this method have shown the effect of diffusion cooling due to the Ramsauer minimum which causes electrons in the high energy tail to have very long free paths and to diffuse to the walls. Molecular hydrogen quenches this effect, and always leads to lower measured values of the coefficient of electron diffusion. In the case of Hg-H<sub>2</sub> mixtures, there are discrepancies at long delay times, and electrons seem to be produced at the glass walls after the majority of the initial electron population has escaped to the walls by diffusion. Thus, electrons are found at times when they have no right to be there, say at tens of milliseconds after the flash. It was shown that these electrons are probably produced as the result of an unidentified wall reaction since the anomalous results can be removed by conditioning the walls and by excluding the volume adjacent to the end walls when measuring the time dependence of the electron density in the cell. Studies have also been made in O<sub>2</sub>-N<sub>2</sub> mixtures. It was found that the attachment coefficient does not scale as the square of the molecule number density but scales somewhere between N and N<sup>2</sup>. The attachment frequency for thermal electrons should scale as N<sup>2</sup> while the energy exchange collision frequency scales as N. This leads to the phenomenon of attachment cooling first demonstrated for electrons by the Unit. Measurements of the rate coefficient for attachment of thermal electrons to SF<sub>6</sub> at room temperature have also been carried out. Studies have also been made of H<sub>2</sub>O-O<sub>2</sub> mixtures, but they were in a preliminary state at the time of my visit, and they will not be discussed here.

Experiments are also being carried out on ion mobilities by time of flight methods to determine ion-atom elastic cross sections in such gases as Hg. In these ion drift tube experiments, the ions can be extracted and identified with a quadrupole mass spectrometer. The experiments are being carried out with very high precision and can be performed at low temperatures. This is a unique feature of the ANU ion mobility experiments. The aim of the ion studies is to develop similar information about ion-atom/molecule interactions as has been, and is being, obtained for electron-atom/molecule interactions. Thus from ion transport coefficients, basic scattering cross sections can be obtained and interaction potentials can be derived. The

fact that Argon, Krypton, Xenon, and Neon ions in different spin states ( $P_{1/2}$  and  $P_{3/2}$ ) have been observed to have different mobilities in their parent gases is of special interest. H. P. Helm started studying this fine structure in the mobility of rare gas atomic ions in Canberra about two years ago. The difference in mobility between the two spin states is a few percent.

It is of interest to use swarm experiments to measure ion charge exchange cross sections at low energies. Presumably such charge exchange cross sections can be obtained by swarm experiments at energies below those of beam techniques except for parallel merging beam experiments. However, parallel merging beam experiments represent a huge capital cost and are tremendously complex. There are few such machines in operation and, furthermore, it is difficult to obtain absolute cross sections from them. Hopefully with swarm experiments one can obtain absolute cross sections down to 0.2 eV and up to a few electron volts by measuring ion drift velocity as a function of  $E/N$  and fitting the data to a cold gas theory developed by Skullerud. Skullerud has found a method of correcting observed data for the thermal motion of the gas. This means that one can use data at very low values of  $E/N$ . If one ignores Skullerud's corrections, one gets significant errors in all cases except in He. In the case of He, the ratio of the energy of ion drift to the energy of the gas is low, but for Neon and Argon, one needs to make corrections.

Another important aspect of ion mobility measurements is the determination of equilibrium constants of such reactions as  $H_4^+ + H \rightarrow H_5^+$ ,  $H_3^+ + H \rightarrow H_4^+$ , and such studies have been carried out at Canberra. At high pressure one will have mostly  $H_4^+$ . Due to the above reaction, the mobility is a function of pressure at a given value of  $E/N$ . If ion mobilities are measured at very low values of  $E/N$  where one has a thermal ion swarm, the variation of mobility with pressure at constant and low  $E/N$  gives one an equilibrium constant for the above reaction. (R. N. Varney, in the United States, attempted such a procedure about 20 years ago.) If one gets the equilibrium constant for several gas temperatures, then one can use the Van't Hoff equation to obtain the heat of dissociation of  $H_5^+$ . If one calculates the heat of dissociation of  $H_4^+$  theoretically for various structures, one might be able to tell what the geometrical arrangement of  $H_4^+$  is. A value of 150 millielectron volts for the heat of dissociation of  $H_4^+$  has been obtained but the result has been disputed, and experiments are being carried out to investigate this matter. Presumably even  $H_7^+$  could be investigated at very low gas temperatures. Work is underway to measure the mobility of lithium ions in helium.

Also, information relating to the fundamentals of  $CO_2$  lasers is of interest to the Unit. They are interested in obtaining vibrational cross sections of  $CO_2$  near threshold to complement the data from beam experiments. Such data would be especially interesting because normal transport theory using the two term expansion of the Boltzmann equation breaks down in  $CO_2$  because of the presence of so many inelastic levels. The presence of inelastic collisions gives many electrons with low energy, and it is the presence of these low energy electrons which leads to a breakdown of the two term Boltzmann expansion. Furthermore, if these low energy electrons undergo an appreciable amount of back scattering, they travel against the field and lose further energy and this enhances the breakdown of the two term approximation. This effect is larger for  $CO_2$  than for any other gas studied so far because the ratio of the sum of all the inelastic cross sections to the sum of all the inelastic and elastic cross sections is very large in  $CO_2$ . (Hopefully, the information that will be obtained for  $CO_2$  will not only be useful for gas laser modelling but also will be useful in the study of interplanetary atmospheres.)

The possibility of a breakdown in the two term Boltzmann expansion is also relevant to recent work on electron drift and diffusion in dilute mixtures of molecular gases in atomic

gases. Earlier it had been shown that if one takes cross sections for  $H_2$  which fit swarm data with the two term Boltzmann expansion and the cross sections for A which also fit swarm data for A, and calculate the transport parameters of mixtures of  $H_2$  and A, one did not get the calculated values using the two term Boltzmann expansion. Frost and Phelps have measured transport parameters in such mixtures and have seen inconsistencies using the two term approximation of up to 20%. However, when the A- $H_2$  measurements of electron mobility and ratio of electron diffusion coefficient to electron mobility experiments were repeated in Canberra (with 1%  $H_2$  in A and with 4%  $H_2$  in A), it was found that the new experimental data agrees with the two term approximation to within 3 1/2% instead of the discrepancy of up to 20% as had been found by Frost and Phelps. The discrepancy of 20% was due to insufficient accuracy in the previous experiments and inaccurate cross sections, and was a false alarm. Calculations with an exact solution carried out at Canberra when compared to results with the two term Boltzmann equation for mixtures of 1 to 10%  $H_2$  in A showed a discrepancy of only as much as up to 1/2% and is not significant. The remaining discrepancy between measured and calculated swarm parameters by the two term expansion may be associated with the 0.3 eV Ramsauer minimum in Argon and the inelastic level of  $H_2$  at 0.5 eV. The electron mobility studies in A- $H_2$  mixtures are now complete. Work has begun on measuring electron mobilities in  $N_2$ -A and  $O_2$ -A mixtures. The aim of this work is to provide data for a systematic study of rotational and vibrational excitation in diatomic gases. The two term solution of the Boltzmann equation breaks down in pure CO. Measurements of electron mobility in CO, and CO-A, and CO-He have been carried out but not yet published. Plans are underway to measure the ratio of electron diffusion coefficient to electron mobility in CO, and the difference between the two term solution and the full solution for CO and the CO mixtures will also be calculated. It is known that in the case of pure CO, the two term Boltzmann expansion gives errors from 10 to 15% when compared with the exact calculation for the ratio of electron diffusion coefficient to electron mobility, although the drift velocity is given satisfactorily by the two term expansion. The electron mobility is affected very little by using the two term expansion but the coefficient of electron diffusion is affected a great deal. The problem here is that the elastic scattering is anisotropic, and this makes for difficulty with the two term expansion. With dilute mixtures of CO and noble gases, the two term expansion should improve because of the increasing importance of elastic cross sections. Measurements of electron mobility in mixtures of CO in A and He have been used to derive a set of cross sections for CO at Canberra. However, it has been shown that different cross sections result from an analysis of drift and diffusion data in pure CO when the analysis is based on the two term Boltzmann expansion. The Unit is very anxious to clear up this problem.

Since my visit a new activity has been added to the Unit with the addition of R. O. Watts, Ph.D. (ANU) and other staff. A new experimental project based on a neutral molecular beam facility has been started. This facility is designed for making high resolution measurements of infrared spectra of molecular clusters and state resolved differential scattering cross section measurements. This is an infrared laser-molecular beam facility and has been designed to accommodate a wide variety of neutral beam experiments. The initial experiments to be performed will involve the use of a single molecular beam and an F-center laser, pumped by a  $Kr^+$  laser, which will be used to study the high resolution infrared spectra of a variety of molecules. On completion of the main beam machine, a variety of crossed beam experiments will be carried out involving Hg-He and  $H_2O$ - $H_2O$ . In addition to this new work Watts has brought his theoretical group, working on the structure and transport properties of fluids, to the Unit.

Perhaps a listing of titles of some recently published and submitted papers, with brief descriptions of the contents of the papers, will help to round out the description of the

Unit's work in gaseous electronics.

- "Electron-Neon Scattering Length and S-Wave Phase Shifts from Drift Velocities," T. F. O'Malley and R. W. Crompton. This is a calculational paper in which electron drift velocity measurements of electrons in neon made by Robertson in 1972 were used to determine the scattering length and the S-wave phase shift.

- "The Diffusion Coefficient for Thermal Electrons in Mercury Vapour at 470 K," R. Hegerberg and R. W. Crompton. The diffusion coefficient for thermal electrons in mercury vapor was measured using the Cavalleri electron density sampling technique. The result indicates that cross sections derived from drift velocity data are superior to those of recent theoretical calculations.

- "Electron Drift Velocities in Air," R. Hegerberg and I. D. Reid. The drift velocities of electrons in dry  $\text{CO}_2$  free air at 293 K were measured at very low values of  $E/N$  (between 0.1 and 1 Townsend). This paper describes measurements at very low electron energies where transport properties of electrons in air are very difficult to measure because of the depletion of electrons by the formation of  $\text{O}_2^-$  by the associative electron process at low electron energies. The present set of measurements was carried out using the drift tube constructed by Reid and Crompton in 1979 in which the electron density in the drift tube is sampled by applying a pulsed RF-field in the detection region and measuring the resultant light output from electron-initiated local discharges.

- "The Drift Velocity of Low Energy Electrons in Oxygen at 293 K," I. D. Reid and R. W. Crompton. These measurements were carried out with the new drift tube technique mentioned in the previously cited paper in the range of 0.14 to 1.4 Townsend. This work also was undertaken to overcome the difficulty in making reliable measurements as a result of electron attachment.

- "The Effect of Attachment Cooling in Oxygen and Oxygen-Nitrogen Mixtures," R. W. Crompton, R. Hegerberg and H. R. Skullerud. Measurements of the attachment rate coefficient for thermal electrons in  $\text{O}_2$  and  $\text{O}_2\text{-N}_2$  mixtures using the Cavalleri electron sampling technique showed an unexpected pressure dependence. This dependence was explained in terms of a perturbation to the expected Maxwellian energy distribution function caused by the selective loss of electrons by attachment at the resonance energy.

- "The Drift Velocity of Electrons in Mercury Vapour at 573 K," M. T. Elford. The drift velocity of electrons in mercury vapor at 573 K was measured using the Bradbury-Nielsen time-of-flight method at vapor number densities ranging from  $3.40 \times 10^{17}$  to  $1.83 \times 10^{17} \text{ cm}^{-3}$  and at  $E/N$  values from 0.1 to 3.0 Townsend. The measured drift velocities increase linearly with mercury vapor number density, the magnitude of the dependence being a function of  $E/N$ . The number density dependence has been attributed to the presence of mercury dimers and the drift velocity corresponding to dimer-free mercury vapor was obtained by extrapolation.

- "The Momentum Transfer Cross Section for Electrons in Mercury Vapour in the Range 0.1 to 5 eV," M. T. Elford. This is a calculational paper in which the momentum cross section for electrons in mercury vapor was derived over the energy range 0.1 to 5 eV from Elford's previous measurements. The cross section has a resonance at 0.5 eV with a maximum value of  $180 \text{ \AA}^2$ .

- "Relativistic Effects in Electron Scattering by Atoms. I. Elastic Scattering of Hg," L. T. Sin Fai Lam. In this paper, the elastic scattering of electrons in the energy range 0 to

25 eV by mercury atoms was investigated by applying a perturbation to the non-relativistic Schrödinger equation. The relativistic correction to the potential was treated using the Pauli approximation and the second order Dirac potential. The non-relativistic Hartree Fock wave function was used to describe the target in the zeroth order approximation. Electron exchange was found to be important. The relativistic correction due to mass variation is important, in particular, in the p-wave scattering which is dominated by a low energy shape resonance. Phase shifts for s, p, d, and f wave scattering were obtained. The total cross section, momentum transfer cross section, differential cross section, and spin polarization were calculated and compared with experiment. (The work on relativistic effects in electron scattering by heavy atoms has now been extended to Be, Mg, Zn, Cd, Kr, Xe, and Rn and includes a study of both direct and indirect effects and calculations of the static dipole polarizability.)

- "The Drift Velocity of Electrons in Carbon Dioxide at Temperatures Between 193 and 573 K," M. T. Elford and G. N. Haddad. The drift velocity of electrons in carbon dioxide decreases linearly with increasing gas number density at a given value of  $E/N$  for gas temperatures less than 293 K. This dependence was attributed to multiple scattering and the data were extrapolated to zero number density to correct for this effect.

#### GASEOUS ELECTRONICS RESEARCH AT THE UNIVERSITY OF NEW ENGLAND

Gaseous electronics research at the University of New England is carried out in the Department of Physics, of which S. C. Haydon is the head. (For a short description of the University, see Appendix III). Haydon received his Ph. D. degree from the University of Wales, working with Llewellyn Jones at Swansea. Interestingly enough, Haydon who is English, had von Engel as his undergraduate tutor at Oxford. His work at Swansea included studies on the measurement of the second Townsend ionization coefficient in nitrogen at pressures and electrode separations where the coefficient had been taken to be zero for years, theoretical investigations of the formative time lags of the electrical breakdown of gases, as well as studies of the role of photoionization in the electrical breakdown of gases. He succeeded J. Somerville as Chairman of the Department of Physics at the University of New England. Since that time he spent a year in 1960 in Massey's laboratory at University College, London, working with J. Hasted, a year in 1969 as a Visiting Fellow at JILA at Boulder working with H. Broida, and a year in 1976 at the Clarendon Laboratories, Oxford, with Colin Webb's laser group.

Whereas the work in gaseous electronics at ANU is largely restricted to cases where ionization of atoms or molecules by electron collision does not occur, the opposite is true of the gaseous electronics work at Armidale. This is a natural outgrowth of Haydon's work on pre-breakdown ionization currents with Llewellyn Jones, although Crompton carried out similar work when he was at Swansea. At Armidale, the electric fields not only produce ionization by collision, but electrical breakdown is also studied. As is also the case at ANU, much of the gaseous electronics work at Armidale is presently motivated by the need of fundamental data in gas mixtures used in gas lasers. This interest in gas mixtures is a fairly recent one at Armidale, and spatial and temporal studies of pre-breakdown ionization growth previously carried out in uniform fields in pure gases such as  $N_2$  have now been extended to gas mixtures:  $N_2$ -NO,  $N_2$ -He,  $CO_2$ - $N_2$ -He, and He- $CO_2$ .

These experiments are carried out in an ionization chamber of which one electrode is a thin gold film on a quartz substrate and the other is bulk copper. Either electrode is capable of being used as the cathode; this allows comparison of the interaction of ions or metastables with gold and copper surfaces. Such studies in mixtures are important because

very few, if any, direct observations of the pre-breakdown development of excitation and ionization have been made in some of these mixtures. Such studies yield first Townsend ionization coefficients and possible identification of the detailed mechanism of secondary ionization. The highest voltage at which such studies can now be carried out is 1500 volts, although plans are underway to extend the voltage to 10,000 volts. The experiments are carried out from pressures of a few Torr to hundreds of Torr.

Although extensive measurements of the first Townsend ionization coefficient in gases have been undertaken over the past seventy years, discrepancies still persist in the measured values even in such a simple gas as "pure" helium, not to mention the almost complete lack of data in gas mixtures. Such studies are complicated by such processes as electron attachment, molecular dissociation, and energy transfer by metastables as well as the possibility of chemical reactions between the dissociation products. In particular, work at Armidale has emphasized the fact that precise values of the first Townsend ionization coefficient can often only be established when the physical processes determining the value of the second Townsend ionization coefficient are well understood. If metastables contribute to secondary ionization, standard methods of analyzing pre-breakdown ionization currents fail because the second Townsend coefficient is not only a function of  $E/N$  but is also a function of the electrode separation. Temporal studies are necessary to find the true first Townsend ionization coefficient where metastables are active.

Thus the ionization studies at Armidale consist of two types, one in which the current in a Townsend discharge is measured at a constant value of  $E/N$  as a function of electrode separation, the so called spatial variation method, and another, at fixed electrode separation, in which a source of external electrons is suddenly applied or removed and the resulting transient current is studied (often called a Molnar experiment). From the shape of the transient current, one can detect the effects of the initially liberated electrons, the resulting positive ions and their effect on the cathode in liberating secondary electrons, and the effects of metastables both in the gas and especially at the cathode.

The results in He-N<sub>2</sub> mixtures show that the secondary ionization shows a slow component characteristic of metastables. However, the metastable species involved is unlikely to be helium, since a recently measured quenching rate for He(2<sup>3</sup>S) by molecular nitrogen yields a lifetime which is more than one thousand times shorter than the observed metastable diffusion times. With the molecular metastable He<sub>2</sub>(<sup>3</sup>Σ<sub>u</sub><sup>+</sup>) expected to have a similar quenching rate, it seems unlikely that many helium metastables reach the cathode. The more probable role for helium metastables must therefore involve Penning ionization processes. Most importantly they will ionize any impurities present in the system rendering them ineffective as quenchers of any N<sub>2</sub> metastables formed.

Measurements of the first Townsend ionization coefficient as a function of  $E/N$  in He-CO<sub>2</sub> mixtures are similar in form to measurements in He-N<sub>2</sub> mixtures, being generally larger and the difference tending to increase at high values of  $E/N$  (>900 Townsend). Some slow component due to metastables was observed for 60 <  $E/N$  < 500 Townsend and detailed investigation at  $E/N = 400$  Townsend showed that the proportion of the fast component tends to increase with increasing gap separation in contrast to the behavior previously observed in pure H<sub>2</sub>, He-N<sub>2</sub>, and N<sub>2</sub>-CO<sub>2</sub> mixtures. Assuming a similar rate of Penning ionization by He(2<sup>3</sup>S) for CO<sub>2</sub> as for N<sub>2</sub>, these metastables would have a lifetime more than 30 times shorter than the observed time constants, so it is again unlikely that the observed slow component is due to helium metastables. The values of the first Townsend coefficient in CO mixtures lie between the corresponding values of pure nitrogen and carbon dioxide. Some slow component of the current was observed, in this case increasing in magnitude with increasing electrode separation, indicating a conventional metastable surface

interaction. The values obtained for the diffusion coefficient of metastables agree fairly well with the calculated value for  $N_2$  molecules diffusing through the mixture. Similar prebreakdown studies are being made in metal vapors.

In addition to the above work on spatial and temporal growth of ionization currents in gas mixtures, studies of electrical breakdown at high frequency (10 MHz) have been carried out for some years at Armidale. This work is supported by a contract with Telecom Australia (this is the trade name of the Australian Telecommunication Commission, a branch of the Australian Ministry of Post and Telecommunications). This work is designed to understand electrical breakdown occurring in high power, high frequency antennas such as was found to occur with a 500 Kw transmitter at Darwin (built in Italy). Usually there were no problems, but at sunrise and sunset there were tremendous discharges so powerful that they damaged and ate into the arrays, although the system was designed with a 40% safety factor. The question arose as to whether such discharges were due to the bodies of insects which were cooked by the radiation. (The array is now down because of the disastrous cyclone in Darwin five years ago). Early work at Armidale about five years ago involved the use of spectroscopic techniques in studies of radio frequency electrical breakdown, and work a few years ago involved observations of radio frequency breakdown occurring in uniform fields at large values of the product of pressure and electrode separation ( $>200$  Torr cm). Most of these studies involved air and nitrogen. The most recent work extends these investigations to non-uniform fields and examines the influence of specific impurities, either created by the r.f. discharges themselves or deliberately added. In this way, a study has been made under conditions that approach more closely those likely to be found in actual situations where pluming phenomena are initiated on antenna systems. Antenna plumes may be triggered by an initial breakdown associated with small, relatively localized breakdown phenomena. Since these local discharges are associated with severe distortion of local electric fields in the presence of sharp objects, it is important to examine breakdown events under nonuniform field conditions. The effects of nonuniform fields proved to have more influence on the breakdown potential than any effects due to changes of metal surfaces or to the presence of surface contaminants such as carbon deposits. Various combinations of electrodes made of stainless steel, brass, aluminum, and copper yielded maximum changes in breakdown voltages in uniform fields no greater than 10%. By contrast, nonuniform fields were found to lead to reductions in breakdown voltage of about 80%. Recently the reduction of breakdown voltage after breakdown events with long pulses has been studied; these reductions are believed to be associated with the production of new species such as  $NO$ ,  $N_2O$ , etc., in the discharge itself. Studies of the influence of impurities from added gases have also been undertaken, with emphasis on the effect of  $CO_2$ .

The problem of defining breakdown in nonuniform fields arises. Generally speaking, the voltage collapse of the oscillographic trace of the r.f. pulse waveform was taken as the criterion for breakdown. However, several consecutive stages in the development of the final discharge in nonuniform fields can be clearly distinguished but not all of them are associated with observable collapses of the oscillographic trace. Only one of these stages is associated with a situation where external irradiation of the discharge gap by ultraviolet radiation to produce photoelectrons from the cathode is significant. This is the first transition to a corona discharge. This particular transition marks the change from a non-self-sustaining discharge in which externally produced electrons are essential, to one where the discharge is self-sustained and independent of the source of externally produced electrons. The nonuniform electric field consisted of a fine needle point protruding through a small aperture in a plane stainless steel electrode of a pair of Rogowski-profiled electrodes. The degree of nonuniformity of the field was controlled by varying the extent of the protrusion of the needle. Measurements were carried out in dry air and in dry

nitrogen at a constant electrode separation of 15 mm for a range of product of pressure and electrode separation of about 200 to 800 Torr cm, and for needle protrusions of 0, 1, 2, 3, and 4 mm for both 10 and 100 microsecond pulses at repetition frequencies of 50 pulses per second. Protrusions of the needle of only a few millimeters markedly reduced the breakdown potential. It is not known whether such large changes in the breakdown fields can be caused by the natural occurrence of sharp points associated with airborne insect populations. It was found that voltage gradients of only 2.5 kV/cm trigger the onset of the corona phase, whereas the maximum voltage gradients on the antenna systems at Darwin were calculated to be in the range of 2.3 to 6.4 kV/cm. This suggests that, irrespective of any possible influence of insects, one should reappraise the generally accepted design criteria for antennas in order to avoid electrical breakdown. Even if one were to establish new design criteria for antennas, it may be that natural phenomena, such as airborne insects, will in any case, in some random and unpredictable fashion, temporarily create the same conditions. At early sunrise or late sunset, insects may be "cooked" by r.f. radiation and the short antennas of these insects may cause breakdown. If so, it needs to be determined whether the incidence of the corona phase can be tolerated. In these studies, attention was paid as to whether the breakdown depends on r.m.s. or peak values of the fields, and it was determined that small volume breakdown events are controlled by r.m.s. rather than by peak values of the applied field. A rather elaborate computer program was developed for calculating the electric field due to the needle protruding into the gap.

We mention briefly that measurements of electronic quenching rates in nitric oxide using two-photon spectroscopy were carried out a few years ago by the gaseous electronics group at Armidale.

Work is also going on in which a prebreakdown phase of ionization growth in Ne is perturbed by a 5 ns pulse from a dye laser and in which the radiation interacts with two metastables in the discharge and sharp changes in the current are observed. These studies are proving particularly interesting and provide information on the magnitude of the depletion of the metastables. It is planned that such studies will be extended in 1981.

Some of the other problems being worked on include the glow to arc transition in  $\text{SF}_6$ , and a study of what causes constriction in an attaching gas.

A list of some publications follow:

- "Laser-induced Opto-galvanic Effects Under Pre-breakdown Conditions in Neon," S. P. Kravis and S. C. Haydon,
- "Studies of Electrical Discharges in High Power H. F. Aerials. III Further Investigations of the Effects of Non-Uniform Electric Fields and Impurities," D. C. Cook and S. C. Haydon, (Telecom Australia Report),
- "Measurement of Electronic Quenching Rates in Nitric Oxide Using Two-Photon Spectroscopy," G. F. Nutt, S. C. Haydon, and A. I. McIntosh, "Time Resolved Studies of the Electrical Breakdown of a Gas at Radio Frequencies," S. C. Haydon and I. C. Plumb,
- "Investigations of Ionization Growth in Gas Mixtures," S. C. Haydon and A. I. McIntosh,
- "Investigations Towards the Understanding of the Properties and Formation of Plumes on R. F. Aerials," S. Dossing, O. Loebert, E. J. Bondarenko (all of Telecom Australia Research Laboratories), S. C. Haydon and S. C. Plumb,

- "Some Theoretical Considerations of R. F. Discharges in Air at Frequencies in the H. F. Band Relating to Plumbing Phenomena," S. C. Haydon and I. C. Plumb, and
- "Combined Spatial and Temporal Studies of Ionization Growth in Nitrogen," S. C. Haydon and O. M. Williams.

#### GASEOUS ELECTRONICS RESEARCH AT THE FLINDERS UNIVERSITY OF SOUTH AUSTRALIA

Gaseous electronics research is being carried out at the Flinders University of South Australia (see Appendix IV) under the leadership of Professor H. A. Blevin of the Institute for Atomic Studies, School of Physical Sciences of the University. Blevin, an experimentalist, received his Ph. D. at the University of New England.

Work going on involves a technique first used by von Engel many years ago, and involves obtaining information about the behavior of electron swarms drifting through a low pressure gas (about 1 Torr) under the influence of an electric field by studying the photon flux emitted by the swarm following electron-atom/molecule collisions. The photon counting techniques used in the early work of von Engel were primitive and resulted in poor statistics and large errors. Developments in photon detection and pulse manipulation have made the method viable and accurate. The crucial factor in these experiments is the relationship between the photon flux and the electron density integrated along the line of sight of the collimator. An exhaustive Monte Carlo treatment of this problem in hydrogen has shown that in hydrogen the photon flux distribution is of the same shape as the electron density distribution. Hence the measured photon distribution may be used to calculate the drift and diffusion parameters of the electron swarm.

In this work, a 30 ns pulse of electrons is supplied to a gas in a uniform electric field below breakdown. There are about  $10^8$  electrons per pulse. These electrons produce electron avalanches and photons. The photons are generally in the range of 800 Å to 2500 Å. In order to convert these ultraviolet photons to visible photons which will pass through a Pyrex viewing port and be detected by a photomultiplier mounted outside this port, a layer of sodium salicylate is placed on the inside of the Pyrex vacuum window. Approximately one photon pulse per 500 electron swarms is recorded. With a gating pulse frequency of 100 kHz, approximately 200 photon pulse signals are analyzed per second. Typically  $2 \times 10^5$  counts are sufficient to reduce statistical fluctuations to an adequate level. The work is being carried out in  $H_2$ ,  $N_2$  and He at a pressure of about 1 Torr. It has been found that He gives rise to long-lived radiation. The electrode separation is 10 cm, and the 30 ns electron pulses are separated by 10  $\mu$ s. From the measurements, one obtains electron mobility, longitudinal and lateral electron diffusion coefficients, and the first Townsend ionization coefficient. These quantities are obtained with an accuracy of 2% for Townsend coefficients, of 2% for electron drift velocities, and about 8% for electron diffusion coefficients. The multiplication in the avalanche in these experiments varies from 1 to 100. It is planned that spectroscopic studies will be made of these avalanches in the future.

The above method of studying electron swarms has the advantage over more conventional methods of being able to study undisturbed swarms remote from any electrode boundaries. More and more workers are calling attention to the fact that the presence of boundaries introduces perturbations into the properties of an electron swarm.

## APPENDIX I

### THE FIRST GASEOUS ELECTRONICS MEETING (GEM)

The first Gaseous Electronics Meeting (GEM) was held in Sydney on February 21-22, 1980 and lasted one and a half days.

The other meetings concerning gaseous electronics are the "Gaseous Electronics Conference" (GEC) first held at Brookhaven National Laboratory in 1948, and since then held annually in the U. S. (one was held in Canada), and the "International Conference on Ionization Phenomena in Gases" first held at Oxford in 1943, and since held every two years in some country in Europe. Australia should be welcomed to the community of countries holding gaseous electronics conferences.

GEM was held on the campus of the University of Sydney, and the organizing committee consisted of H. A. Blevin, R. W. Crompton, S. C. Haydon, J. J. Lowke, and H. K. Messerle. All these names appear elsewhere in this report.

I was not present at GEM; my visit to Australia occurred three months later. However, some comments about the meeting based on the printed program of abstracts and on conversations with participants will be made.

Six sessions were held. They were entitled:

- breakdown,
- swarms (two sessions),
- transient plasmas,
- MHD (magnetohydrodynamics) and arcs, and
- lasers.

Thirty three papers were given, three of which were of non-Australian origin (at the first GEC in 1948, there were no foreign papers). These three papers were entitled:

- "The Physics and Application of Inductively Coupled RF Plasma Torches," E. L. Bydner, B. S. Liley, G. P. Miller, and C. B. Ong, University of Waikato, New Zealand,
- "Photodetachment Threshold Behavior," W. C. Lineberger, University of Colorado, and
- "Electron Transport Coefficients in CO<sub>2</sub> Laser Plasmas," K. J. Nygaard, R. A. Sierra, H. L. Brooks, and S. R. Foltyn, University of Missouri, Rolla.

The work of the first of these three papers was described in this *Bulletin* 5 (2), 46-62 (1980). Of the remaining 30 papers, 20 were carried out in institutions which I visited and many of which are described in the body of this report.

An interesting feature of GEM was the after dinner speech of Professor Sir Leonard G. H. Huxley. I heard a tape of this address while I was in Australia and was much moved by it. It was a highly personal account of Sir Leonard's impressions of Sir John Townsend. Townsend's magnificent accomplishments and all too human weaknesses were described. It would be good to have this address in print and available for all to read. I was fortunate enough to have had a luncheon meeting with Huxley (and Crompton) on Huxley's 78th birthday at the Commonwealth Club in Canberra. His reminiscences of Townsend and

other well known names in gaseous electronics were fascinating in their objectivity, frankness, and in their insightfulness. He spoke of Townsend's enormous talent with his hands and of the fact that he had been trained as a mathematician. He spoke of the hard feelings between Townsend and J. J. Thomson, and that J. J. Thomson did not treat Townsend fairly about Townsend's measurement of the charge on the electron. Townsend never visited Cambridge after receiving his degree until after the death of J. J. Thomson. I also learned that Huxley had been Llewellyn Jones' tutor at Oxford. Huxley has recorded some of his thoughts, some of which are not to be made available until after his death.

## APPENDIX II

### THE AUSTRALIAN NATIONAL UNIVERSITY

#### INTRODUCTION

The Australian National University (ANU) is located in Canberra, the capital of Australia, in the Australian Capital Territory. The Australian Capital Territory is within the confines of the state of New South Wales. Although the federation of Australian states occurred in 1901, the site of the capital was not selected until 1908, at which time it was an uninhabited area. Canberra now has a population of 250,000 and is the show place of the nation. It is a completely planned city and is still under development. Queen Elizabeth opened an elaborate (and widely criticized) new high court building two days before my visit.

ANU was originally set up in 1946 as a wholly postgraduate and research university granting only graduate degrees in order to reverse the brain drain of scholars and scientists who were leaving Australia because of lack of adequate research opportunities.

Canberra University College was established in the 1930s. It prepared students, mostly part-time, and mostly commonwealth public servants for undergraduate and some graduate degrees from the University of Melbourne. In 1960, ANU and Canberra University College were merged under the name of the Australian National University.

(Before proceeding to a detailed discussion of ANU, it would be well to, in general, briefly discuss Australian universities. All universities in Australia [and New Zealand] are publicly supported institutions. There are no private universities in Australia. This is in marked contrast to Japan and the United States where about 80 percent and 20 percent of all college and university students attend private institutions, respectively. With perhaps one exception, all universities in Australia, regardless of size, grant the Ph. D. degree. [In New Zealand, there are no exceptions to this rule.] This, again, is in marked contrast to Japan and the United States where there are a great number of institutions of higher education that do not offer the Ph. D. degree. In Japan, only eleven publicly supported universities are allowed to grant the Ph. D. degree in science and engineering. There is, thus, a fundamental difference of philosophy between New Zealand and Australia on the one hand, and Japan and the United States on the other. One point of view is that a nation benefits best by having a spirit of research and scholarship at the most advanced level at all universities. The other point of view, held in Japan and the United States, is that scholarship thrives best if talent and resources are highly concentrated in a relatively few places.)

Since 1960, ANU has been both an ordinary university involving undergraduate and graduate studies within the School of General Studies, and an exclusively graduate activity

known as the Institute for Advanced Studies. It was this Institute for Advanced Studies which comprised ANU before 1960. There are, thus, two routes to receive a graduate degree at ANU: (1) through the School of General Studies and, (2) the Institute of Advanced Studies. This dual arrangement is not only unique in Australia, but as far as I know, does not exist anywhere else. There is no graduate course work or formal teaching of any kind in either the School of General Studies or the Institute of Advanced Studies. At ANU, there are no engineering courses of any kind.

In addition to the School of General Studies and the Institute of Advanced Studies, ANU has a number of multidisciplinary research centers and units, such as the Center for Resource and Environmental Studies, the Humanities Research Center, and the North Australia Research Unit, based in Darwin, and the Mt. Stromlo and Siding Spring Observatories Services Unit.

## THE SCHOOL OF GENERAL STUDIES

The School of General Studies enrolls about 5,000 undergraduate and 600 graduate students. Of the 600 graduate students, about 200 are working for the Ph. D. degree. The School has Faculties of Arts, Asian Studies (the only full faculty in Australia devoted to this subject), Economics, Law, and Science.

The Faculty of Science of the School of General Studies consists of thirteen departments:

- applied mathematics,
- biochemistry,
- botany,
- chemistry,
- forestry (this is the only university department of forestry in Australia,
- geography,
- geology,
- physics,
- psychology
- pure mathematics,
- statistics,
- theoretical physics, and
- zoology.

Some classes in chemistry and physics now only have four or five students. Two faculty members in physics are leaving and they are not being replaced.

## THE INSTITUTE OF ADVANCED STUDIES

The Institute of Advanced Studies now consists of seven research schools (in 1960 there were only four). They are:

- Research School of Biological Sciences,
- Research School of Physical Sciences,
- Research School of Chemistry (formerly part of the Research School of Physical Sciences),
- Research School of Earth Sciences (also formerly part of the Research School of

- Physical Sciences),
- Research School of Pacific Studies,
- Research School of Social Sciences, and
- The John Curtin School of Medical Research (Curtin was an Australian prime minister; Howard Walter (Baron) Florey, winner of the Nobel prize for isolation and purification of penicillin, was the School's first director and was heavily involved in the initial planning of the school).

Each research school may consist of a mixture of organizations called departments, units, and occasionally groups. A unit is generally built around a particular individual.

These research schools have a policy of appointing at least 50 percent of their academic staff to non-tenured positions "to give them the flexibility which enables them to operate at the forefront of international science and scholarship." The academic staff of the research schools have no responsibility for undergraduate students, and most of their 400 graduate students, about half from overseas, are working for the Ph. D. degree. Tenured faculty are either Professors, Professorial Fellows, Senior Fellows (equivalent to Readers), or Fellows. About 50 percent of the tenured staff are Fellows. The non-tenured staff are either Senior Research Fellows, Research Fellows, or Post Doctoral Fellows. About 50 percent of the non-tenured staff are Post Doctoral Fellows. Ph. D. students are known as Scholars.

#### THE RESEARCH SCHOOL OF PHYSICAL SCIENCES

The first director of the Research School of Physical Sciences was Mark (later Sir Mark) Oliphant, a native of Adelaide. He served as Director of the School from 1950 to 1963. Beginning in 1971, he served a term as Governor of South Australia, and there is a bust of him in the garden outside of Government House in Adelaide.

There are between 100 and 110 academic staff members in the School, and as mentioned above, about 50 percent are tenured. Appointments to non-tenured staff positions are for three years, and extendable to five. Postdoctoral appointments are made, but not for more than two years. A student may only take four years at most to obtain the Ph. D. (American universities take note!). All students are full-time and all are on scholarships; they do no undergraduate teaching.

The departments, units, and the one group of the School (with their heads) are:

- nuclear physics, (John Newton),
- solid state physics (spectroscopy of solids), (Allan Runciman),
- engineering physics (solar energy, laser physics, information theory), (S. Kaneff),
- plasma physics group, (S. Hamburger),
- applied mathematics (this department also does experimental physics), (B. Ninham),
- astronomy (located at Mt. Stromlo, 25 kilometers from Canberra, also uses Anglo-Australian Observatory located at Sidings Springs), (D. Mathewson),
- diffusion research unit (nature and structure of liquids, primarily using tracer-diffusion experiments), (R. Mills), and
- ion diffusion unit (R. W. Crompton).

## APPENDIX III

### THE UNIVERSITY OF NEW ENGLAND

The University of New England is situated about five kilometers northwest of the center of the city of Armidale, New South Wales. Armidale is a cathedral city located in the New England tablelands at an altitude of 1000 meters above sea level and has a population of approximately 22,000. It is about 580 kilometers north of Sydney and about 460 miles south of Brisbane and is the center of a thriving agricultural and pastoral area (sheep, cattle, and fruit).

The University originated in 1938 as the New England University College, a branch of the University of Sydney. Since 1954, it has been a completely independent institution. It now has a total enrollment of about 8000 students, half of which consists of internal students and the other half are external students.

There are six faculties and two Schools in the University:

- Faculty of Arts (established in 1938),
- Faculty of Science (established in 1940),
- Faculty of Rural Science (established in 1956),
- Faculty of Economic Studies (established 1971),
- Faculty of Education (established in 1968),
- Faculty of Resource Management,
- The School of Natural Resources (established in 1970),
- and
- The School of Biological Sciences (established in 1974).

In the Faculty of Science, master and doctor degrees are offered in biochemistry, botany, computing science, geology, geophysics, mathematics, organic chemistry, physical and inorganic chemistry, physics, physiology, psychology, and zoology.

Besides the physics activities covered in this report, the Department of Physics also has extensive activities in acoustics, biophysics, and solid state physics. The main emphasis in the acoustics work is on understanding the acoustical behavior of musical instruments such as organ pipes, woodwinds, harpsicords, particularly in relation to harmonic development and to transient effects. Theoretical work and related experiments deal with the effects of non-linear behavior in various acoustical systems. The biophysics activities in physics consist of acoustical analysis of the auditory and sound producing systems of simple animals. This work is being carried out in cooperation with the Department of Neurobiology of the Australian National University. The solid state physics activities include experimental and theoretical work on the physics of ice and water, nuclear magnetic resonance studies with special reference to aluminum alloys, properties of amorphous semi-conductors, energy and structure calculations for crystal surfaces and interfaces, theoretical studies of hydrogen in metals, and theoretical studies of nuclear quadrupole relaxation in liquids and of nuclear dipole-dipole interactions in solids.

Research facilities in the physics department include a 500 kW transmitter operating at or near the gyrofrequency at a field station eight kilometers from Armidale. An ionosonde is in regular operation. A 13 cubic meter freezer room exists for ice studies at -25 °C with liquid nitrogen facilities for lower temperatures. Single crystal X-ray diffraction cameras including a precession camera are also available. High power pulsed nitrogen and tunable dye lasers together with high resolution Fabry Perot instrumentation

for narrow band output are available for laser studies. Other equipment includes image converter, image intensifier and fast multi-channel analyzer facilities for nanosecond time resolved studies, a 0-10,000 gauss air-cooled 30 cm diameter pole-face electromagnet and a quadrupole filter spectrometer.

Enrollments are presently down at the University and the physics department (two professors, three associate professors, and four senior lecturers) is at present considered to be overstaffed by four and a half people. One of the reasons for the enrollment problems of institutions such as the University of New England is the rather recent (10 years) establishment of about 80 job-oriented Institutes of Advanced Education in Australia.

Funds for research at the University of New England are not nearly as adequate as they are at ANU.

The Physics faculty consists of: Professors N. H. Fletcher and S. C. Haydon (Ph. D. Wales); Associate Professors F. H. Hibberd (Ph. D. Sydney), R. A. Smith (Ph. D. Sydney), and G. A. Woolsey (Ph. D. Belfast); Senior Lecturers J. M. Brettell (Ph.D. Monash), A. I. McIntosh (Ph. D. ANU), B. M. Seppelt (D. Phil. Oxon), and C. A. Scholl (Ph. D. Monash).

#### APPENDIX IV

##### THE FLINDERS UNIVERSITY OF SOUTH AUSTRALIA

The Flinders University of South Australia had its origins in 1958 when it became evident that the University of Adelaide located at North Terrace in Adelaide would have serious accommodation problems in 1965 because of size limitation on its 30 acre city site. In 1961 the South Australian Government made available to the University of Adelaide the 370 acre site known as Bedford Park seven miles south of the city. The original plan was that Bedford Park would be an academically autonomous campus of the University of Adelaide. Students would graduate from Bedford Park with degrees of the University of Adelaide, but the professors at Bedford Park would be responsible for the design of their own courses and for the structure of the degrees. However, towards the end of 1965, the South Australian government decided to make the University of Adelaide at Bedford Park a fully autonomous university under the name of the Flinders University of South Australia, and the university opened in 1965.

The university has eight schools:

- School of Humanities,
- School of Social Sciences,
- School of Mathematical Sciences,
- School of Physical Sciences,
- School of Biological Sciences,
- School of Medicine,
- School of Earth Sciences, and
- School of Education.

As of 1979, there were 53 professors and 270 other academic staff. In 1978, there were 3920 students.

The physics faculty consists of: Professors M. H. Brennan (Ph. D. Sydney), I. E. McCarthy (Ph. D. Adelaide), H. A. Blevin (Ph. D. New England), and Erich Weigold (Ph. D.

ANU); Readers R. G. Stoer (Ph. D. Adelaide), I. R. Jones (Ph. D. Wales), and I. R. Afnan (Ph. D. MIT); and Senior Lecturers E. L. Murray (Ph. D. Adelaide), A. L. McCarthy (Ph. D. Pittsburgh), John Fletcher (Ph. D. Keele), P. Teubner (Ph. D. Adelaide), M. Phillips (Ph. D. British Columbia), and R. Cahill (Ph. D. New South Wales). There is very interesting work going on in atomic physics at Flinders, both experimental and theoretical, as well as plasma physics. These activities will be described in a forthcoming report.

## LOW LEVEL RADIOACTIVITY LABORATORY, KANAZAWA UNIVERSITY

Francis A. Richards

The Low Level Radioactivity Laboratory (LLRL) is part of the Faculty of Science of Kanazawa University. The staff includes the director, Professor Masanobu Sakanoue, Associate Professor Kazuhisa Komura, the technician, and one secretary. The work of this small group is augmented by resident graduate and undergraduate students, visiting research scientists in residence, and by collaboration with other scientists throughout Japan. It is the only university laboratory devoted to basic studies involving low level radioactivity, and thus serves as a national facility. There are several institutes within the organization of the Ministry of International Trade and Industry (MITI) concerned with the many applied problems involved in radioactivity and the development of nuclear energy, but none is dedicated to basic research on low-level radioactivity. The laboratory is the upshot of a recommendation made by the Japan Science Council in 1968 for the study of environmental radioactivity. The science council recommended that the institute be within one of the national universities.

In 1973, Kanazawa University asked the Ministry of Education, Science, and Culture to form a center for the study of environmental radioactivity as a first step toward the establishment of an institute. Unlike most Japanese national universities, Kanazawa has a large land area in a district with little industrial or other pollution. In response to the proposal, the Ministry approved the establishment of a laboratory (as a first step toward a center?) in 1975, and the laboratory was opened in May 1976. It is in Tatsukokuchi-machi, Ishikawa Prefecture, about an hour's drive from the main campus in Kanazawa.

The laboratory building is two stories high with a third story over part of the building and basement laboratories. In addition to the fixed installation, a feature of the laboratory is a mobile unit, the Rolling Low Level Radioactivity Laboratory, which is used for *in situ* measurements around the country. Its basic equipment is an ORTEC portable gamma germanium (lithium) or pure germanium spectrometer.

The mission of the laboratory is the study of the environment, and areas of research include the atmosphere; the hydrosphere with emphasis on hydrothermal waters, ground water, and ocean water; soils; rocks; and meteorites. Geochemistry and geochronology are studied using carbon-14, lead-210, uranium and thorium series dating techniques. Other general topics include environmental radioactive dose measurements, not only gross determinations but, also, identification of sources of radioactivity; contamination of the environment by nuclear facilities, especially plutonium contamination around the world; the cosmochemistry of meteorites; low levels of radioactivity in the human body; and applications of low-level counting techniques to nuclear chemistry, physics, and tracer studies.

The Rolling Low Level Radioactivity Laboratory (RLLRL) is unique among Japanese university laboratories; only two governmental institutes, the Japanese Atomic Energy Research Institute (JAERI) and the Scientific Institute of Physical and Chemical Research under MITI, have similar capabilities. Consequently, the laboratory attracts many visiting university scientists interested in environmental radioactivity.

The RLLRL has been used in many investigations during the life of LLRL. The original portable Ge(Li) gamma spectrometer was used for *in situ* measurements of radioactivity in nuclear energy plants, of which there are over ten in the Kanazawa area. Measurements have also been made in a uranium mine and a uranium processing plant. An

interesting application has been to determine radioactive residues from nuclear explosions. The fishing boat *Lucky Dragon* (Dai-5 *Fukuryu Maru*) was exposed to radioactive fallout in March, 1954; the boat is now preserved in a special housing for scientific observation. Originally, levels of cobalt 60 and cesium 137 on the boat were high; in recent tests americium 241 and europium 155 are still detectable. The portable gamma spectrometer has also been taken to the bomb sites at Hiroshima and Nagasaki, where it was used to estimate residues of europium 151 and 154 and, of cobalt 60. These are isotopes formed by neutron bombardment; by determining their activities at different distances from the epicenter of the Hiroshima bombing, an attempt was made to determine the thermal neutron doses at different distances from the epicenter. Such counts can be made with the *in situ* system whereas they cannot be made on samples returned to the laboratory because of the interference from other radiation and shielding difficulties.

The portable *in situ* spectrometer has a number of advantages. Shielding is unnecessary because the environment (not the laboratory) is being sensed. Atmospheric radioactivity can be measured from such places as a bridge or over seawater, and the radioactivity of hot spring waters can be measured directly by dipping the spectrometer, which is cooled with liquid nitrogen, directly into the hot spring. The only problem in such measurements is to protect the instrument from the high environmental humidities.

An important program of the laboratory, begun in 1965 before the laboratory was founded, is the study of highly toxic radioactive plutonium in the environment. Since 1976, the distribution of plutonium in biological samples, soils, and marine samples has been in progress, and analytical procedures for the determination of plutonium have been developed and modified. In 1977, the analytical methods used at the laboratory were compared by cross-check analyses by different laboratories. Samples of airborne dust and of soil containing refractory oxide of Pu (ignited 1600°C) were analyzed.

Five other laboratories were involved; The Technical Center for Environmental Pollution of Ibaraki Prefecture, The Power Reactor and Nuclear Fuel Development Corporation, The National Hygienic Laboratory, The Hygienic Institute of Fukui Prefecture, and the Japanese Chemical Analysis Center. The airborne dust samples were collected shortly after a Chinese nuclear test in September, 1977. Cross-check analyses of samples collected between September 17 and 24 showed over 1 picocurie of  $^{239} + ^{240}\text{Pu}$  per about 10,000 cubic meters of air; samples collected between September 30 and October 9 had dropped to less than 0.5 picocuries in comparable samples. The cross-check analyses of soil containing refractory plutonium oxide involved different methods for the dissolution of the samples with the participation by the National Institute of Radiological Sciences. Differences from laboratory to laboratory were significant, but much less so than the differences arising from the different chemical treatments of the samples.

The plutonium content of the Indian Ocean, the Celebes Sea, and the waters around Japan have been investigated, using samples collected by the *Hakuko Maru* in 1976 and 1978. The highest levels of Pu  $^{239} + ^{240}$ , up to 8 or  $9 \times 10^{-4}$  picocuries per liter, were observed around Japan; low values were observed south and west of Australia. In the northern Sea of Japan the ratio of  $^{238}\text{Pu}$  to  $^{239} + ^{240}\text{Pu}$  tended toward a minimum at a depth of a little less than 100 m and then tended to increase to 3000 m, but the error bars also tended to increase with depth. On the other hand, the concentrations of  $^{239} + ^{240}\text{Pu}$  tended toward a maximum at around 500 m and then decreased with depth. Maximum concentrations were on the order of  $8 \times 10^{-4}$  picocuries per liter. Observations on sea water and marine sediments suggest that about 4% of the plutonium reaching the sea surface enters the bottom sediments.

Plutonium and other isotopes have been determined in soil and lake and marine sediments; generally the levels of plutonium, potassium 40, thorium, uranium, and cesium 137 decrease rapidly in soils as would be expected. Cesium 137 and plutonium have also been determined in a variety of environmental samples, such as pine needles, seaweed, and mosses. The analyses have included other fallout nuclides such as beryllium 7, manganese 54, cobalt 57 and 58, zirconium 95, rubidium 103, rhodium 106, antimony 125, cesium 141 and 144, and potassium 40.

A method to determine ratios of 228 radium to 226 radium by high resolution gamma ray spectrometry under very low background conditions has been developed and applied to studies of the Indian Ocean and the Seto Inland Sea. Because of the different half-lives of the two isotopes (Ra 226, 1600 years; Ra 228, 5.7 years) the ratios can be used to evaluate mixing process. The Japanese methodology differs from that in general use in the United States, which involves the long-term storage of samples and determining daughter radioisotopes, either thorium 228 or actinium 228. The Japanese method involves concentration from 400 to 800 liters of seawater test by co-precipitation with barium sulfate and ferric hydroxide. The ferric hydroxide is dissolved in acid and used for plutonium analysis and the barium sulfate residue is returned to the laboratory and subjected to low background gamma spectrometry for determination of the radium isotopes. Radium 226 is distributed rather uniformly in ocean waters, but such is not the case with Ra 228, which is introduced from the continental shelf, and then decreases rapidly both by radioactive decay and by mixing with Ra 228 poor "older" oceanic waters. Concentrations of Ra 228 of 597 disintegrations per minute per 1000 liters were observed near shore in the Andaman Sea (Indian Ocean), but dropped off quickly to the south (offshore). On the other hand, the Ra 226 content was rather uniform at around 55 dpm/1000 liters.

One of the projects of Associate Professor Komura has been the study of environmental radioactivity in the Antarctic. Low-level determinations have been made on geological samples and snow from Ross Island and the Dry Valleys, working out of New Zealand's Scott Base. Only initial determinations were made on samples collected in 1976, but a wide variety of samples is now on hand awaiting analyses.

Professor Kenji Konishi of the Department of Earth Science, Faculty of Science, Kanazawa University, has been collaborating with Professors Sakanoue and Komura on the dating of reef-building organisms using radioactive isotopes. More than 100 coral samples have now been dated. On one reef, samples were dated according to species, elevation above sea level, and location on various terraces.

Liquid scintillation counting of the radioactive carbon-14 from the coral calcium carbonate is a highly sensitive technique. The counting is in benzene formed from either carbon or carbonate according to the scheme:

- |                            |   |
|----------------------------|---|
| 1. Carbon combustion       | $C + O \rightarrow CO_2$                                      |
| 2. Carbon dioxide fixation | $CO_2 + Ba(OH)_2 \rightarrow BaCO_3$                          |
| 3. Carbonate decomposition | $BaCO_3 + H_3PO_4 \rightarrow CO_2$                           |
|                            | $CaCO_3 + H_3PO_4 \rightarrow CO_2$                           |
| 4. Carbide preparation     | $2CO + 10Li \rightarrow Li_2C_2 + 4Li_2O$                     |
| 5. Acetylene production    | $Li_2C_2 + 2H_2O \rightarrow C_2H_2 + 2LiOH$                  |
| 6. Benzene synthesis       | $3C_2H_2 \text{ (plus vanadium catalyst)} \rightarrow C_6H_6$ |

More recently perchloric acid,  $HClO_4$ , has been substituted for the phosphoric acid ( $H_3PO_4$ ) because reaction of the latter with calcium carbonate precipitates calcium phosphate,

$\text{Ca}_3(\text{PO}_4)_2$ , which tends to occlude carbon dioxide. Counting is in an Aloka low background liquid scintillation spectrometer with lead shielding and an anticoincidence system. For carbon-14 counts from coral samples, 100-minute counts are usually repeated 10 times; background counts are about 2.5 counts per minute.

A non-destructive dating technique based on the  $^{226}\text{Ra}/^{238}\text{U}$  ratio has been applied to fossil corals from the Quaternary. The method is "non-destructive" in that the sample is not chemically altered although it is ground and powdered. Gamma radiation from the samples is measured using two heavily shielded germanium detectors, while low energy gamma rays were measured by a low energy photon spectrometer (LEPS). The method has been used to date corals as much as 110,000 years old, well beyond the useful limits of the C-14 method (about 40,000 years).

The low levels of radioactivity of interest to the Low Level Radiation Laboratory pose special contamination problems. Modern steel and iron has been subjected to artificially introduced radioisotopes, and so iron products produced before World War II are in demand for shielding. Sources that have been used are old battleship iron and an old steel block used in a hydroelectric power generator manufactured in 1931 by Hitachi, Ltd. Plans are underway for the establishment of a low background level radiation laboratory in a tunnel through a hydroelectric dam for studies of cosmogenic radiation.

The wide variety of investigations undertaken by the personnel of the laboratory and their collaborators is reflected in a listing of some of the projects:

- measurement of background radiation using Ge(Li) detectors.
- measurement of environmental radioactivity using or Sc(Ge(Li) spectrometry.
- radionuclides in Antarctic ice samples.
- measurement of fallout nuclides from Chinese nuclear detonations.
- determination of the U, Th, and K contents of standard rock JG-1.
- U, Th, K, and  $^{137}\text{Cs}$  contents of the sediments from Lake Suwa and from Osaka Bay.
- determination of  $^{137}\text{Cs}$  in milk. Samples from Hokkaido and Iwate were analyzed using a Ge(Li) detector and a Low Background Counter. The levels determined by the two instruments generally agreed, and counts from Hokkaido milk were generally higher than those from Iwate.
- the half-life of long-lived  $^{93}\text{Nb}$ .
- measurement of the FOM (figure of merit) for  $^{54}\text{Mn}$ .
- shielding of Ge(Li) and Ge(Li) - LEPS detectors. A problem in the accurate determination of very low levels of radioactivity is that of proper shielding materials. The germanium (lithium) detector is shielded by 20 cm of steel and 5 cm of mercury giving about 25 counts per minute in the 0.1 to 2.7 Mev energy range. Various combinations of various thicknesses of lead, iron, copper, and mercury have been tested. In higher energy regions (2.0 to 4.0 MeV) a combination of 20 cm of iron and 1 cm of copper is somewhat more effective than the 20 (or 30) cm of iron and 5 cm of mercury.
- measurements of radiation exposure rates and radon-222 in hot spring waters using the portable Ge(Li) detector. Values of exposure rates in R/hour have been determined for uranium, thorium, potassium 40, cesium 137, and "others", i.e., contributions from short-lived fallout nuclides including beryllium-7.
- radionuclides in Japanese soil. Activities reported in picocuries per gram, have been determined in samples from Hokkaido, Honshu, and Kyushu, for  $^{210}\text{Pb}$ ,  $^{210}\text{Bi}$ ,  $^{210}\text{Po}$ ,  $^{238}\text{U}$ ,  $^{232}\text{Th}$ ,  $^{235}\text{U}$ , and  $^{137}\text{Cs}$ .
- radionuclides in thermal spring waters and ground waters.
- concentrations of  $^{137}\text{Cs}$  and  $^{210}\text{Pb}$  in soil.

- studies of the radiochemical purity of  $^{99m}\text{Tc}$  solutions.
- non-destructive gamma ray measurement of meteorite samples.
- meteorite collected in Antarctica during the joint Japan-United States Meteorite Search Program [*Scientific Bulletin*, 3(3), 23] were determined using the Ge(Li) gamma ray spectrometer.  $^{26}\text{Al}$ ,  $^{40}\text{K}$ ,  $^{22}\text{Na}$ ,  $^{54}\text{Mn}$ ,  $^{60}\text{Co}$ , and  $^{137}\text{Cs}$  have been counted on meteorites weighing from 59 to 862 grams. Measuring times of 9800 to over 12,000 minutes were used.
- *in situ* fluorescence x-ray analysis using a portable LEPS (Low energy photon spectrometer) detector. The technique has been used to estimate lead contamination in various locations.
- depth profiles of  $^{137}\text{Cs}$  and  $^{239+240}\text{Pu}$  in soil, lake sediment, and marine sediment. Various soil samples and sediment from Lake Suwa and Osaka Bay were investigated. In most soils the activities decrease rapidly with depth, but in the lake sediment both  $^{137}\text{Cs}$  and  $^{239+240}\text{Pu}$  appeared to go through maximum at about 10 cm, a minimum at a little less than 20 cm, and then to increase with greater depth.
- residual radioactivities related to *Dai-5 Fukuryu Maru* (Lucky Dragon #5). The fishing boat *Lucky Dragon* was accidentally exposed to radioactive bomb fallout in March, 1954. The boat is now preserved in a special building for various studies. ( $^{137}\text{Cs}$  and  $^{60}\text{Co}$  are still detectable.)
- behavior of  $^{239+240}\text{Pu}$  and  $^{241}\text{Am}$  at rather high levels accumulated in soil.
- activation analyses of rare earth elements in rocks and minerals. A large number of relatively short-lived radioactive nuclides are formed by the activation of rare earth elements, including  $^{140}\text{La}$ ,  $^{141}\text{Ce}$ ,  $^{142}\text{Pr}$ ,  $^{147}\text{Nd}$ ,  $^{153}\text{Sm}$ ,  $^{152}\text{Eu}$ ,  $^{153}\text{Gd}$ ,  $^{160}\text{Tb}$ ,  $^{145}\text{Dy}$ ,  $^{166}\text{Ho}$ ,  $^{171}\text{Er}$ ,  $^{170}\text{Tm}$ ,  $^{175}\text{Yb}$ , and  $^{177}\text{Lu}$ .
- application of  $^{230}\text{Th}/^{234}\text{U}$  dating to Late Pleistocene aboriginal corals.
- confirmation of the Middle Pleistocene in raised coral beds by non-destructive  $^{226}\text{Ra}$  -  $^{238}\text{U}$  dating.

It is evident that the activities of the laboratory are wide ranging and of considerable environmental interest. The laboratory itself appears to be very well equipped. Most of the detectors are from the United States. Equipment includes a wide variety of detectors, counters, a computer (a PDP 11/10 with a 16 K memory), a well-equipped laboratory for chemical separations and preparations, and the mobile laboratory are available to the staff and visiting investigators.

## LEADING SEMICONDUCTOR RESEARCH IN CHINA

Leonard J. Brillson

During the period of 14-29 September 1980, I visited a number of universities and institutes in the People's Republic of China. From September 14-19, I visited Fudan University in Shanghai and presented a series of three Physics Department lectures entitled "UHV Techniques for Characterizing Metal-Semiconductor Interfaces," "Chemical Reaction and Local Charge Redistribution at Metal-Semiconductor Interfaces," and "Atomic Redistribution at Metal-Semiconductor Interfaces and their Electronic Effects." My audience consisted of 30-40 young scientists and several senior faculty members-all of whom appeared to understand slowly-spoken English without an interpreter. Occasionally, my host Professor Hsi-teh would interject a few comments in Chinese to emphasize a particular point. Questions afterward were directed primarily toward theoretical modelling and toward practical Si and narrow band gap semiconductor interfaces.

Fudan University is in the process of recovering from the Cultural Revolution during which almost all undergraduate and graduate training of new scientists stopped for about eight years. During this period, Professor Hsieh, now Vice President of the University, spent time working in an electronics factory. A large building program is now underway on the campus which dates back to 1905. Professor Hsieh has received substantial funding to replace the crude home-built vacuum apparatus and electronics systems I viewed with modern equipment made in the U.S. The Chinese are proud to point out, however, that they make their own lock-in amplifiers (at the Changshi Lunsin Instrument factory). Yu-Lin Tsu was anxious to develop a kelvin probe apparatus, which I was able to help her with. Xun Wang has developed a DLTS apparatus for characterizing deep levels in semiconductors. I saw DLTS apparatus at almost every institute or university I visited in China.

On September 17, I visited the Institutes of Metallurgy and Ceramics in Shanghai. The Institute of Metallurgy has eight departments or laboratories which deal with:

- large scale integrated circuits,
- magnetic devices, bubbles, and superconductors,
- new semiconductor technologies,
- III-V compound semiconductor metallurgy and devices,
- physics of metals and semiconductors,
- corrosion of metals,
- chemical analysis services (including mass spectrometry),
- electronic instrumentation and machine shop.

I saw crystal growth of III-V compound semiconductors oriented toward solar cells, ion implantation, and metallurgy of GaAs. These included  $10^{16}$  InP undoped with  $< 3000$  impurities  $\text{cm}^{-3}$  and  $10^{15}$  n-GaAs grown by a horizontal Bridgeman method with  $10^5$   $\text{cm}^{-2}$  dislocation density.

There are a total of 1100 people in the Institute of Metallurgy, of which 660 are scientists and less than 40 are the equivalent of a trained Ph.D. There are also quite a few young institute scientists studying abroad-six in the United States, two in France, two in Germany, two in the United Kingdom, and four in Japan. The Institute of Metallurgy used to encompass other disciplines which have now been split off into other institutes. For example, the Institute of Ceramics in Shanghai split off in 1958. Others include the Institutes of Noble Metals in Kunming and Nonferrous Mining in Changsha. The Institute

of Metallurgy and, in particular, the LSI laboratory has a close relationship with electronics factories. Other laboratories work closely with computer factories and even sign financial contracts. There is a high interest in semiconductor processing. They produce GaAs (but not Si) FET's and integrated circuits with a 1-6% yield. No CCD's are made here. They claim to be the only Institute making ECL, CMOS, and FMOS devices. They have made GaAs solar cells with a 15.5% efficiency ( $V_{OC}=0.925$ ,  $I_{SC}=22.7$ ,  $FE=0.74$ ), GaInAs photodetectors by VPE with a minimum  $10^{13}$  and average  $10^{14}$  purity ( $N_D-N_A$ ), and Si-implanted GaAs MESFET's at 125keV. They also grow GaAs by Czochralski methods. They are expecting the Sin Yang province factory to provide them with an MBE apparatus within one year. They are also laser annealing Si with a ruby laser at power densities of  $4.25 \text{ joules/cm}^2$ . Xie Lei Ming has developed a new method of annealing Si on sapphire by directing the laser through the Si on to a graphite plate in contact with the sapphire. This heats the graphite and crystallizes the sapphire. This group has also built a 20W lag laser. Xie Lie Ming and Zhou Zhu Yao are having a 600kV ion implantation machine built to replace the present 125keV unit. The new machine, and a new building to house it, is scheduled for 1983. Here I also saw an Auger electron spectroscopy system made in China. The system's base pressure is  $3 \times 10^{-10}$  Torr and the CMA has a resolution of 0.3% with a signal-to-noise of  $>200$  for Cu. Zhang Chien-Si is using this apparatus currently to study the Al-Si interface. The experimental facilities here were much better than at Fudan University. Here and elsewhere, the Chinese are anxious to use the most modern techniques and equipment to fabricate and analyze semiconductor devices.

The Institute of Ceramics has 1000 personnel of which 300 are scientists. There is only one institute of ceramics in China, and it is here that xerographic photoreceptor work is carried out. The institute has laboratories for:

- crystal chemistry,
- crystal physics,
- quartz, synthetic quartz, amorphous materials, conventional glasses, heat-resistant materials, and electrooptic materials.

Only inorganic materials are studied. I saw a demonstration of a-As<sub>2</sub>S<sub>3</sub> used for holographic storage. The visual image was of rather low quality. Institute staff claimed that this holographic image could be transferred electrophotographically to paper. They also demonstrated the measurement of a photo-induced discharge curve for Se-As glass. The discharge measured with a chart recorder required 1-3 seconds. After their demonstration, I was literally surrounded by Institute scientists with their director and informed that their films degraded electrically from ozone generated during the charging step. How could this be avoided, they wished to know. They questioned me closely for almost ten minutes on this point, and also on how to avoid dark decay and light fatigue. My response to all such questions was that Xerox had solved this and many other such problems years ago, and that I was not familiar with the proprietary details. My impression was that the Chinese could probably fabricate a xerographic photoreceptor, but only one of low quality.

The Institute of Ceramics is also trying to develop low-loss optical fibers. Theoretical values of 2-3db/kM at  $\lambda=0.85\mu\text{m}$  have been determined for P<sub>2</sub>O<sub>5</sub>-SiO<sub>2</sub> fibers with a 60  $\mu\text{m}$  core and a B<sub>2</sub>O<sub>3</sub>-SiO<sub>2</sub> cladding of 140  $\mu\text{m}$  diameter. They need to reduce impurity levels to below 10ppb since actual attenuations are much higher. An ovonic memory device Ge<sub>1-x</sub>Te<sub>x</sub>S<sub>2</sub>Sb<sub>2</sub> was also shown which displayed a 5ms erase and 15ms write mode. They are also interested in making low resistance contacts to a-Si.

On September 23, I visited the Peking University physics department. The physics department enrollment includes 700 undergraduates and 50 graduate students. The head of

the physics department, Qin Guo Gang will be visiting the U.S. to work with C.T. Sah at the University of Illinois. Twenty teachers and ten graduate students have already been abroad. The department concentrates on low temperature magnetic physics, metal physics, lasers, optical spectroscopy, and semiconductor physics. The physics department has been doing semiconductor device work for the past ten years, but semiconductor physics work began only two years ago. Even though the physics department has much more freedom for basic research today, emphasis is on deep levels in semiconductors, new techniques to prepare laser diodes, glass fiber transmission ( $<10\text{dB/kM}$  achieved) LPE growth, and heterojunction analysis, i.e., studies of parameters which limit device performance. Liu Hong-du and coworkers have developed a new method of thermally oxidizing GaAs for stripe geometry DH lasers and semiconductor integrated optics. Another group is studying recombination effects at metal-semiconductor and semiconductor heterojunction interfaces by a variety of techniques. In general, the solid state physics which I saw would be considered quite practical device electronics here in the U.S. From September 21-25, I was the guest of the Chinese Academy of Sciences in Beijing, which was specifically arranged by Professor Kun Huang (of Born and Huang fame), director of the Institute of Semiconductors in Beijing. On September 24, I presented a lecture entitled "Atomic Redistribution at Metal-Semiconductor Interfaces and their Electronic Effects." Here I lectured to approximately 100 Institute staff members via an interpreter. The two hour lecture was followed by 45 minutes of questions which focused on the experimental techniques and on extensions of the results to practical semiconductor devices.

The Institute of Semiconductors in Beijing has approximately 1000 staff members including 600 university graduates but only about 20 senior professionals. The Institute is short of trained professionals and is awaiting the first crop of trained graduates to pass through the educational system since the Cultural Revolution. The major laboratories within the Institute are concerned with,

- crystal growth: low dislocation crystals for high power devices such as microwave oscillators,

- bipolar circuits: 20 new types of circuits developed, some with 1 ns delay time vs. 10ns in TTL,

- new techniques: electron beam, x-ray, soft x-ray, and ion implantation facilities. (While the Institute has much Chinese equipment such as the first SEM built in China, Professor Huang feels that they are "not properly equipped yet" and are very anxious to import instrumentation to replace what they have),

- MOS circuits: random access memory, CCD's, SOS. They have problems with their Si-SiO<sub>2</sub> interfaces,

- microwave applications: Si and GaAs short-wave oscillators with mixing in the 4mm (past), 2mm (present), and submillimeter (future) wave range. They have developed Gunn diodes for studying the physics of domain motion and breakdown,

- optoelectronics: development of lasers for long wavelengths (presently working on quaternaries), fiber coupling, Si avalanche detectors, quaternary detectors, deep level studies via DLTS, role of defects in GaAs laser aging and,

- physical and chemical analysis: EPR spectroscopy, photoluminescence, IR absorption, Raman spectroscopy, electron microscopy, and Auger electron spectroscopy. The Auger laboratory contained some of the latest equipment from Physical Electronic

Industries. There is apparently great support for surface science, particularly for semiconductor device analysis.

As with the Institute of Metallurgy in Shanghai, the Institute of Semiconductors is trying to negotiate financial contracts with factories. There is, in fact, a large overlap in the activities of many of the Academy institutes. This is not viewed as a serious problem by Huang since the various institutes may contract with different electronic factories across China. This implies some duplication of effort in both research and production.

The scientists I met at each institute and university were quite open in showing their facilities, their successes, and their failures. They are anxious to learn the very latest techniques for fabricating semiconductor devices and are trying to acquire the most advanced instrumentation. At this time, they are receiving considerable financial support from their government.

## THE TENTH INTERNATIONAL SYMPOSIUM ON FAULT-TOLERANT COMPUTING

Dale G. Platteter

The Tenth International Symposium on Fault-Tolerant Computing (FTCS-10) was held in Kyoto, Japan on October 1-3, 1980. This conference was the tenth in a series of annual meetings sponsored by the Technical Committee on Fault-Tolerant Computing of the IEEE Computer Society, and the first of its kind in Asia. Over 30 professional engineers and computer scientists from over 13 countries attended three days of technical presentations concentrating on methods for improving the reliability and maintainability of advanced computer systems. Presentations covered during FTCS-10 included research efforts by private industry and universities on the latest techniques for building fault-tolerant computer networks.

The Kyoto Kaikan (Kyoto Municipal Congress Hall) was the site for 73 presentations on the following subjects:

- design of fault-tolerant computer circuits and systems,
- analysis of computer system performance and reliability,
- test generation and fault diagnosis,
- applications of digital coding techniques,
- computer software reliability and testing.

A technical program committee, staffed by scientists from over 30 countries, reviewed 188 papers before selecting the final list of 73 that were presented. Because of the number of presentations and the limited duration of the meeting most sessions were held in parallel.

The United States contributed 49 percent of the papers while Japan and France authored 22 percent and 18 percent respectively. A growth in the research activity of Canada, Italy, West Germany, Poland, Norway, United Kingdom, U.S.S.R., China, Australia, and Malaysia was illustrated by excellent contributions from these countries. Papers by U.S. authors came equally from private industry and universities, while the majority of foreign papers were presented by universities.

### CONCERNS OF FAULT-TOLERANT COMPUTING RESEARCH

Fault-tolerant computer design techniques are primarily used in high reliability applications to improve performance beyond that experienced in "commercial" systems. The techniques are incorporated into systems (sometimes at the cost of size and power) for the sole purpose of improving reliability.

Fault-tolerant computers are found in telephone switching networks, aircraft landing systems, power generating stations, spacecraft, and advanced weapons systems. Memory designers are using fault-tolerant error correcting schemes to decrease the failure rates of high technology semiconductor memories. The Navy's Standard Electronic Module (SEM) program uses fault-tolerant circuit design techniques to help protect against "birth defects" inside complex integrated circuits. Applications where extended performance and reliability are essential to the mission are prime candidates for fault-tolerant designs.

To construct a fault-tolerant network, one purposely configures an architecture with

redundant internal structures. This could take the form of several identical internal units, each performing the same task in synchronization and each capable of operating alone if the other fails. Within the computer architecture, critical data paths are usually monitored for errors and special circuitry is assigned for correcting faults, removing bad units, and performing software recovery routines. A properly configured fault-tolerant system circumvents errors automatically and reconfigures itself without user intervention.

Redundancy in fault-tolerant structures can be found within the internal hardware and software. Self-checking circuits, error detecting and correcting logic, watchdog timers, multiple data busses, and totally reconfigurable subsystems are just some of the hardware techniques in use today. Software fault-tolerance takes the form of multiple programs to perform the same task, data reasonableness testing, redundant data sampling, redundant storage, self-test, diagnostic programs, and recovery routines. Most "self-repairing" or fault-tolerant computers use a combination of both software and hardware techniques.

The idea of using "self-repairing" computers is particularly attractive for remote military applications where maintenance personnel and repair parts are not available. In this situation, fault-tolerant systems could alert the operator with a "maintenance indicator" and then continue to function correctly for several months before repair is required. The ability to execute properly in the presence of component and program failures (which normally cause stoppages) is the most important benefit of fault-tolerant design.

#### NEW APPLICATIONS FOR FAULT-TOLERANT COMPUTERS

Fault-tolerant configurations have recently become popular for increasing the initial "testing confidence" of large-scale integrated circuits. These complex devices contain as many as a million transistors in a single package. Exhaustive functional testing of these parts has become impossible. Looking for manufacturing-induced "birth defects" requires thousands of hours using sophisticated test equipment.

To solve this problem, integrated circuit manufactures are designing fault-tolerant structures within their complex devices to increase manufacturing yields and increase field reliability at the same time. Reliability conscience users are finding that triplicating components with high failure rates is also a cost effective solution to the testing problem.

#### TECHNICAL PRESENTATIONS AT FTCS-10

The technical presentations were separated into 18 major sessions covering all facets of fault-tolerant computing research. Testing and system diagnosis were the major concerns as 18 papers dealt with these subjects. Testing of microprocessors and programmable logic arrays headed the list. Techniques for hardware design verification (getting "bugs" out before production) was an important topic of this year's symposium.

A complete digest of papers from FTCS-10 is available from the IEEE Computer Society, 5855 Naples Plaza, Suite 301, Long Beach, California 90803. In most cases, individual copies of papers may be obtained by directly writing each author. The complete list of presentations is given below for this purpose.

The conference papers were grouped into the following categories:

#### COMMERCIAL SYSTEMS

Name & Address	Title of Paper
- L. A. Boone Sperry Univac Blue Bell, PA, U.S.A.	Availability, reliability, and maintainability aspects of the Sperry Univac 1100/60
- M. Adham Amdahl Corp., M/S 249 P.O. Box 470 Sunnyvale, CA 94086, U.S.A.	Deterministic reset for the Amdahl 470 V/6 computer
- K. Tomita Nippon Electric Company 1-10, Nissnin-cho, Fuchu Tokyo 183, Japan	A highly reliable computer system-its implementation and result

#### CODING FOR MASS STORAGE

- M. Goto Gifu University Nakamonzen-cho, Kakamigahara Gifu 504, Japan	Rates of unidirectional 2-column errors detectable by arithmetic codes
- T. R. N. Rao Department of Computer Science P. O. Box 44330, USL Lafayette, LA 70504, U.S.A.	Unidirectional error codes for shift register memories
- A. K. Bhatt Sperry Univac 2276 Highcrest Road Roseville, MN 55113, U.S.A.	Random-double-track-error correction in magnetic tapes

#### CORRECTION OF MEMORY FAULTS

- W. C. Carter IBM T.J. Watson Research Center P.O. Box 218 Yorktown Heights, NY 10598 U.S.A.	Design analysis of codes and their self-checking circuit implementations for correction and detection of multiple b-adjacent errors
- S. Kaneda and F. Fujiwara Musashino Electrical Communications Laboratory NTT, 3-9-11 Midoi-cho Musashino, Tokyo 180, Japan	Single byte error correcting-double byte error detecting codes for memory systems

- R. S. Swarz  
Digital Equipment Corporation  
146 Main Street  
Maynard, MA 01754, U.S.A.

A design process state  
preservation on storage unit  
failure

- A. V. Kuznetsov  
Institute for Problems of  
Information Transmission  
USSR Academy of Sciences  
Moscow, U.S.S.R.

Masking triple fixed defects  
in memory

#### DESIGN VERIFICATION

- F. Maruyama and T. Uehara  
Fujitsu Laboratories Ltd.  
1015 Kamikodanaka, Nakahara-ku  
Kawasaki 211, Japan

Hardware verification and  
design error diagnosis

- S. B. Akers  
General Electric Company  
3-223 Electronics Park  
Syracuse, NY 13221, U.S.A.

A procedure for functional  
design verification

- A. Lewinski  
Institute of Automatics  
Warsaw Technical University  
Warsaw, Poland

System for symbolic hardware  
algorithm verification

#### OPERATING SYSTEMS AND SYNCHRONIZATION

- C. B. Weinstock  
SRI International  
333 Ravenswood Avenue  
Menlo Park, CA 94025, U.S.A.

SIFT: system design and  
implementation

- C. Gaudé  
Cerci, 56 rue Roger Salengro  
94120 Fontenay Sous Bois  
France

Design and appraisal of  
operating systems matched  
in selective active  
redundancy

- R. Valette  
LAAS, 7 avenue du Colonel  
Roche  
31400 Toulouse, France

Monitors petri nets and error  
confinement

- S. M. Miranda  
CERISS - INRIA Université  
des Sciences Sociales  
Place Anatole France  
31042 Toulouse Cedex, France

DLP: a fault-tolerant  
decentralized locking  
protocol for distributed  
data base

## SOFTWARE FAULT AVOIDANCE AND TOLERANCE

- K. Okada, K. Futatsugi  
and K. Torii  
Electrotechnical Laboratory  
1-1-4 Umezono Sakuramura  
Niihari, Ibaraki 305, Japan  
Reliable program derivation in  
functional languages by  
applying Jackson's design  
method
- F. Cristian  
Computing Laboratory  
University of Newcastle  
upon Tyne  
NE1 7RU, United Kingdom  
Exception handling and  
software-fault tolerance
- J. P. Banatre  
LRISA Universite de Rennes  
Campus de Beaulieu  
35042 Rennes Cedex, France  
A language framework for the  
reliable programming of  
distributed applications
- K. Hiraishi  
Nippon Electric Company Ltd.  
3B-101 Sakuradai Midori-ku  
Yokohama 227, Japan  
Application of the fault-  
tolerant deadline mechanism  
to a satellite on-board  
computer system
- J. P. Black and  
D. E. Morgan  
Department of Computer Science  
University of Waterloo  
Waterloo, Ontario, N2L 3G1  
Canada  
An introduction to robust  
data structures

## LSI TESTING

- J. P. Hayes  
University of Southern  
California  
Department of Electrical  
Engineering  
University Park  
Los Angeles, CA 90007  
U.S.A.  
A calculus for testing complex  
digital systems
- C. Robach and G. Saucier  
Laboratory IMAG, B.P. 53X  
38041 Grenoble Cedex  
France  
Application oriented micro-  
processor test method
- M. El-Lithy  
Laboratory E.E.A. de  
l'E.N.S.E.M.  
2 rue de la Citadelle  
B.P. 850, 54011 Cedex  
France  
Bit-sliced microprocessor  
testing-a case study

- S. J. Hong and  
D. L. Ostapko  
IBM T.J. Watson Research  
Laboratory  
P.O. Box 218  
Yorktown Heights, NY. 10598  
U.S.A.

FITPLA: A programmable logic  
array for function  
independent testing

- H. Fujiwara  
Department of Electrical  
Engineering  
Osaka University  
Yamadakami, Suita  
Osaka 565, Japan

Universal test sets for  
programmable logic arrays

#### TEST GENERATION

- P. Goel  
IBM Data Systems Division  
Poughkeepsie, NY 12602  
U.S.A.

An implicit enumeration  
algorithm to generate tests  
for combinational logic  
circuits

- K. Kinoshita  
Hiroshima University  
1-1-89, Higashisenda-machi  
Naka-ku, Hiroshima 730  
Japan

Test generation for  
combinational circuits by  
structure description  
functions

- S. Funatsu  
Nippon Electric Company Ltd.  
1-10, Nisshin-cho, Fuchu  
Tokyo 183, Japan

Digital fault simulation in  
bi-directional bus circuit  
environments

- E. J. McCluskey  
Computer System Laboratory  
Stanford University  
Stanford, CA 94305, U.S.A.

Structured design for  
testability to eliminate  
test pattern generation

#### TESTING-PROBABILISTIC APPROACHES

- K. K. Saluja  
Department of Electronic  
and Computer Engineering  
University of Newcastle  
N.S.W. 2308, Australia

Transition count testing of  
sequential machines

- K. Inagaki and S. Yajima  
Department of Information  
Science  
Faculty of Engineering  
Kyoto University  
Sakyo-ku, Kyoto 606, Japan

Autonomous testing and its  
application to testable  
design of logic circuits

- S. Ohteru  
Department of Applied Physics  
Waseda University  
3-4-1 Okubo, Shinjuku-ku  
Tokyo 160, Japan

Digital circuit test system  
using statistical method

- R. David and  
P. Thevenod-Fosse  
I.E.G. Laboratoire d'Automatique  
de Grenoble  
B.P. 46, 38400  
Saint-Martin-d'Heres, France

Random testing of intermittent  
faults in digital circuits

#### MODELING FOR EVALUATION

- D. P. Siewiorek  
Computer Science Department  
Carnegie-Mellon University  
Pittsburgh, PA 15213, U.S.A.

A performance-reliability  
model for computing systems

- R. A. Rutledge  
IBM Corporation  
P.O. Box 390, Department D18  
Building 707-1  
Poughkeepsie, NY 12602  
U.S.A.

The reliability of memory  
subject to hard and soft  
failures

- J. M. DeSouza  
Laboratoire d'Automatique  
et d'Analyse des Systemes  
du Centre National de la  
Recherche Scientifique  
7 avenue de Colonel Roche  
31400 Toulouse  
France

A unified method for the  
benefit analysis of fault-  
tolerance

- B. E. Helvik  
ELAB-Electronic Research  
Laboratory  
Norwegian Institute of Technology  
N-7034 Trondheim NTH  
Norway

Periodic maintenance, on the  
effect of imperfectness

- R. K. Iyer  
Computer Systems Laboratory  
Stanford University  
Stanford, CA 94305  
U.S.A.

A statistical study of  
reliability and system load  
at SLAC

## COVERAGE EVALUATION

- W. C. Carter  
IBM T.J. Watson Research  
Center  
P.O. Box 218  
Yorktown Heights, NY 10598  
U.S.A.

Remarks on the probability of  
detecting faults

- J. J. Stiffler  
Raytheon Company  
528 Boston Post Road  
Box 3190  
Sudbury, MA 01776  
U.S.A.

Robust detection of  
intermittent faults

- R. K. Iyer  
Computer Systems Laboratory  
Stanford University  
Stanford, CA 94305, U.S.A.

A study of the effect of  
uncertainty in failure rate  
estimation on system  
reliability

- B. Decouty  
IRISA-INRIA  
Campus de Beaulieu  
35042 Rennes Cedex, France

An evaluation tool of fault  
detection mechanisms  
efficiency

## EVALUATION AS A DESIGN AID

- G. Granello  
Telettra S.p.A. Switching Division  
Via Matei 20  
20064 Gorgonzola, Milano  
Italy

AFDT1 redundancy plan

- T. S. Liu  
Honeywell Information Systems  
Phoenix, AZ  
U.S.A.

Availability analysis of  
tree-structured computer  
communication systems

- M. Dal Cin  
Institut für Information-  
sverarbeitung  
Universität Tübingen  
Kostlinstr 6, 7400 Tübingen  
West Germany

Self-testing and self-  
diagnosing multicomponent  
systems

- J. C. Laprie  
LAAAS-CNRS  
7 Avenue de Colonel Roche  
31400 Toulouse, France

Dependability modeling of  
safety systems

- A. L. Gnanirov  
Computer Science Department  
UCLA, 3531 Boelter  
Los Angeles, CA 90024, U.S.A.

On the performance of software  
fault-tolerance strategies

#### SELF-CHECKING

- Y. Tohma  
Tokyo Institute of Technology  
2-12-1 Ookayama Meguro-ku  
Tokyo 152, Japan

Signal reliability evaluation  
of self-checking networks

- R. David  
I.E.G. Laboratoire  
d'Automatique de Grenoble  
B.P. 46  
38402 Saint-Martin-d'Heres  
France

Sequentially self-checking  
circuits

- D. J. Lu  
Center for Reliable Computing  
ERL 226A  
Computer Systems Laboratory  
Stanford University  
Stanford, CA 94305  
U.S.A.

Self-checking linear feedback  
shift registers

- C. Landrault  
Laboratoire d'Automatique et  
d'Analyse des Systemes  
LAAS-CNRS  
7 Avenue de Colonel Roche  
31400 Toulouse, France

Design specifications of self-  
checking detection processor

- Y. Tohma  
Tokyo Institute of  
Technology  
2-12-1 Ookayama Meguro-ku  
Tokyo 152, Japan

Design of self-checking  
asynchronous sequential  
circuits

- M. Courvoisier  
LAAS-CNRS  
7 Avenue de Colonel Roche  
31400 Toulouse, France

A self-testing arbiter circuit  
for multimicrocomputer  
systems

- Y. W. Yang  
Shanxi Microelectronics  
Research Institute  
Lintong, Shanxi  
People's Republic of China

Threshold  $I^2L$  totally self-  
checking circuits

## SYSTEM LEVEL DIAGNOSIS

- S. M. Reddy  
Electrical and Computer  
Engineering  
University of Iowa  
Iowa City, IO 52242, U.S.A.

Some extensions to the theory  
of system level fault  
diagnosis

- D. R. Mueller  
Sperry Univac  
2276 Highcrest Road  
Roseville, MN 55113, U.S.A.

Support processor based system  
fault recovery

- D. K. Pradhan  
School of Engineering  
Oakland University  
Rochester, MI 48063, U.S.A.

A fault-diagnosis technique  
for closed flow networks

## MULTIPLE FAULT TEST GENERATION

- V. K. Agarwal  
McGill University  
Department of Electrical  
Engineering  
3480 University Street  
Montreal, Canada

Predictions of multiple fault  
coverage capability

- M. Abramovici  
Bell Telephone Laboratories  
Naperville, IL 60544, U.S.A.

Fault diagnosis sequential  
circuits based on an effect-  
cause analysis

## DISTRIBUTED SYSTEM ARCHITECTURES

- A. L. Gnary  
Computer Science Department  
UCLA, 3531 Boelter  
Los Angeles, CA 90024  
U.S.A.

A highly reliable, distributed  
loop network architecture

- T. Kikuno  
Faculty of Engineering  
Hiroshima University  
3-8-2 Sendamachi Naka-ku  
Hiroshima 730, Japan

Local controllers for packet  
switching network

- C. K.-C. Leung  
Laboratory for Computer  
Science  
MIT, 545 Technology Square  
Room 532  
Cambridge, MA 02139  
U.S.A.

Design of fault-tolerant  
packet communication  
computer architecture

## FAULT-TOLERANT LOGIC DESIGN

- J. A. Abraham and  
D. D. Gajski  
Coordinated Science Laboratory  
University of Illinois  
at Urbana-Champaign  
Urbana, IL 61801, U.S.A.

Easily testable, high speed  
realization of register-  
transfer-level operations

- D. G. Platteter  
Naval Weapons Support Center  
Building 2917  
Crane, IN 47522, U.S.A.

Transparent protection of  
untestable LSI micro-  
processors

- Y. Tohma  
Tokyo Institute of Technology  
2-12-1 Ookayama Meguro-ku  
Tokyo 152, Japan

Logic design of fault-tolerant  
arithmetic units based on  
data complementation  
strategy

- Y. Koga  
Department of Electrical  
Engineering  
National Defense Academy  
1-10-20, Hashirimizu  
Yokosuka 239, Japan

Logic elements for fail-safe  
circuit design

## DEDICATED DESIGNS

- M. Morganti  
Telettra S.p.A. -  
Switching Division  
Via Mattei 20  
20064 Gorgonzola Milano  
Italy

A microprocessor based control  
unit for high availability  
applications

- P. L. Fu  
Computer Systems Laboratory  
Stanford University  
P.O. Box 9183  
Stanford, CA 94305, U.S.A.

Consistency unit for fault -  
tolerant multiprocessors

- M. T. Liu  
Department of CIS  
Ohio State University  
2036 Neil Avenue  
Columbus, OH 43210, U.S.A.

Design of reconfigurable  
front-end processor for  
computer networks

- K. Kawakubo  
Railway Technical Research  
Institute of Japanese  
National Railways  
8-38 Hikari-cho 2-chome  
Kokubunji-shi 185, Japan

The architecture of a fail-  
safe and fault-tolerant  
computer for railway  
signalling device

- H. H. Huang  
GTE Products Corporation  
P.O. Box 205  
Mountain View, CA. 94042  
U.S.A.

Fault-tolerant design of a  
modern receiving system

## SECOND U.S.-JAPAN SEMINAR ON HIGH PRESSURE RESEARCH: APPLICATIONS IN GEOPHYSICS

E. F. Skelton

One example of the excellent spirit of cooperation which exists between the U.S. and Japan was the first joint seminar on high pressure science and geophysics held in 1976 at the University of Hawaii. Following the success of that meeting, and because of the many scientific advances which have been made in the intervening years on both sides of the Pacific, it was decided to hold the second U.S.-Japan Seminar on High Pressure Research: Applications in Geophysics.

This seminar was held January 12-15, 1981, at Hakone, Japan and was sponsored jointly by the U.S. National Science Foundation and the Japan Society for the Promotion of Science. There were appropriately 70 scientists attending the conference and the picturesque surroundings of the Hakone National Park provided an excellent backdrop for the many scientific discussions. Although this was principally a U.S.-Japan program, with almost an equal number of papers coming from each country, there were also singular representations from other nations, viz. Australia, France, West Germany and U.S.S.R. The formal proceedings were divided into seven sessions on the following topics:

- instrumentation and pressure calibration,
- elasticity, attenuation and rheology of the crust and upper mantle,
- mechanical properties and melting of the crust and upper mantle,
- geophysics and geochemistry of the mantle,
- high pressure phase transformations and crystal chemistry,
- crystal chemistry and crystal growth, and
- shock wave experiments.

Although time and space do not permit reviewing all of the almost fifty papers presented at the conference, some of the high lights are offered below in hopes of suggesting the tenor and flavor of the conference; a list of titles and authors is given at the end of this article.

Collaborating scientists from the Universities of Osaka and Kobe reported the development of a new technique in which sintered diamond anvils were used to replace the WC-anvils previously employed in a triple stage high pressure apparatus for the production of much higher working pressure with lower applied loads. For example, with the sintered diamond anvils, the semiconductor-to-metallic transition in GPa, which is known to occur at a pressure of about 22 GPa (=220 kbar) was observed at a ram load of only 25 tons, whereas four-times that load was required to induce the same transition with the WC-anvils. The system has been used to study a number of pressure induced phase transitions in, e.g.,  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub> at ca. 50 GPa, BP at ca. 40 GPa, and CaO at ca. 60 GPa. The upper pressure limit of this improved system is, as yet, uncertain; however, estimates based on linear extrapolations beyond the highest calibration point (50 GPa) suggest static pressures in excess of a megabar (100 GPa).

For many years, high pressure scientists using diamond-anvil cells, have made use of the pressure induced shift in the wavelength ( $\lambda$ ) of the fluorescent R-lines from ruby to measure pressure. At the conference, scientists from the National Institute for Researches in Inorganic Materials at Tsukuba reported that under hydrostatic pressure conditions, the breadth of this line can also be used to simultaneously estimate the temperature, thereby providing a single (P,T)-gauge device. In general, when both the

pressure and temperature of the cell are varied, it is expected that the resulting change in wavelength,  $\Delta\lambda(P,T)$ , would be the result of that due solely to pressure  $\Delta\lambda(P)$ , that due solely to temperature  $[\Delta\lambda(T)]$ , and a cross-term, which would be a function of both  $P$  and  $T$ . However, these recent experiments indicate that this cross term is negligibly small and therefore the total line shift  $[\Delta\lambda(P,T)]$  can be considered simply as the sum of  $\Delta\lambda(P)$  and  $\Delta\lambda(T)$ , and since the latter term can be determined from the line broadening, both  $P$  and  $T$  can be determined from a single measurement.

There were also several papers presented at the conference reporting the very rapid acquisition of precision X-ray diffraction data by energy dispersive diffraction techniques with a diamond-anvil cell. Developments were reported independently by researchers from the University of Tokyo and West Germany of a conical window collimator for use with large area, solid state detectors which permits the capture of essentially all the x-ray photons scattered through the same Bragg diffraction angle. In one case, the precision in d-spacing determination was estimated to be about 0.2% after a measurement of 1 minute and 0.1% after a 30 minute measurement. However, in a paper from the U.S. Naval Research Laboratory even faster high pressure diffraction experiments were reported. By illuminating the pressure cavity with synchrotron produced x-rays, d-spacings could be determined to a precision of less than 0.1% for exposures as short as 10 seconds.

A paper coming from the Seismological Laboratory at California Institute of Technology reported a new technique for measuring the temperature at the leading edge of a shock wave. Essentially the light emitted at the shock front is measured by a series of photo diodes. It is found that these data can be correlated in most, but not all, cases with the temperatures predicted from the usual shock temperature calculations. There was a rather lively and excited discussion regarding this method which promises to be very useful for future shock wave studies.

The team from the Hawaiian Institute of Geophysics presented a number of papers, but perhaps one of the most thorough was their compilation of work on phase transitions in the rutile structured dioxides, viz.,  $\text{TeO}_2$ ,  $\text{PbO}_2$ ,  $\text{SnO}_2$ ,  $\text{TiO}_2$ ,  $\text{RuO}_2$ ,  $\text{MnO}_2$ , and  $\text{GeO}_2$ . They discovered a new phase transition in  $\text{TeO}_2$  at about 16 GPa, which is interesting because first known example of a pressure induced second-order phase transition was discovered several years ago in this material at 0.9 GPa. Also of interest in this regard is their report of another second-order phase transition, this occurs in  $\text{MnO}_2$  at about 16.7 GPa. It will be of interest to see if there is a mode softening in this materials as has already been observed in  $\text{TeO}_2$ .

Sato and Ida of the Ocean Research Institute of Tokyo University reported the determination of self-diffusion coefficients of ions in alkali halides by a new technique involving low frequency impedance measurements. The authors believe that it can be readily applied to the determination of diffusion coefficients at high pressures.

A paper coming from the Seismological Laboratory at California Institute of Technology reported a new technique for measuring the temperature at the shock front by means of a series of photo diodes. There was considerable discussion regarding the merits of this technique.

Although time and space limitations do not permit a complete review of every paper presented at the conference, suffice it to say that there was a wholesome exchange of both ideas and very recent results to the mutual benefit of all the conferees.

The conference topics, with papers and authors, are listed below:

Instrumentation and pressure calibration

- S. Endo  
K. Ito  
Triple-stage high pressure apparatus using sintered diamond anvils
- M. Wakatsuki  
K. Ichinose  
A wedge-type cubic anvil high pressure apparatus and its application to material syntheses research
- J. C. Jamieson  
J. N. Fritz  
M. H. Manghnani  
Pressure measurement by internal standards in X-ray diffraction studies at high temperature
- O. Shimomura  
S. Yamaoka  
N. Nakazawa  
O. Fukunaga  
Application of a diamond-cell to high-temperature and high-pressure experiments
- E. F. Skelton  
Rapid high pressure structural information from energy dispersive analyses of diffracted synchrotron radiation
- W. B. Holzapfel  
W. May  
Recent improvements in energy dispersive X-ray diffraction with the diamond cell
- T. Yagi  
S. Akimoto  
Rapid X-ray measurements to Megabar range - static compression of  $\alpha\text{-Fe}_2\text{O}_3$  -

Elasticity, attenuation and rheology of the crust and upper mantle

- I. Jackson  
H. Niesler  
The elasticity of periclase to 3GPa: Implications for equations-of-state of close-packed oxides and silicates
- W. A. Bassett  
H. Shimizu  
E. M. Brody  
Pressure dependence of elastic moduli of forsterite by Brillouin scattering in the diamond cell
- D. J. Weidner  
The effect of crystal structure and composition on elastic properties of silicates

- H. Shimizu  
E. M. Brody  
H. K. Mao  
P. M. Bell  
Brillouin measurements of n-H<sub>2</sub>  
and n-D<sub>2</sub> in the pressure  
range 5 - 200 kbar at room  
temperature
- K. W. Katahara  
M. H. Manghnani  
Pressure dependence of Q in  
selected rocks
- H. Sato  
Y. Ida  
Diffusion coefficients of ions  
in alkali halides determined  
from a low-frequency impedance  
measurement
- S. Karato  
N. Toriumi  
T. Fujii  
M. Ogawa  
Dynamic recrystallization and  
high-temperature and high-  
pressure rheology of olivine

Mechanical properties and melting of the crust and upper mantle

- M. Shimada  
H. Yukutake  
Fracture and deformation of  
silicate rocks at high  
pressures
- H. Mizutani  
H. Spetzler  
Time-dependent mechanical  
properties of rocks at high  
pressure
- D. L. Kohlstedt  
R. F. Cooper  
Microstructure of ultramafic  
rocks containing a small  
percentage of melt
- H. S. Waff  
J. R. Bulau  
Experimental studies of near-  
equilibrium textures partially  
molten silicates at high  
pressure
- D. H. Eggler  
D. R. Baker  
Reduced volatiles in the system  
C-O-H: Implications to mantle  
melting, fluid formation, and  
diamond genesis
- L. L. Perchuk  
D. H. Lindsley  
Fluid-melt interaction under  
high pressure conditions and  
genesis of some platform magmas
- E. Ohtani  
M. Kumazawa  
T. Kato  
T. Irifune  
Melting of silicates at elevated  
pressures and its implications  
to the chemical stratification  
in the mantle

## Geophysics and geochemistry of the mantle

- O. L. Anderson  
R. Boehler  
Y. Sumino      The Hildebrand equation of state  
for geophysical minerals
- M. Kumazawa  
E. Ohtani  
M. Kato  
A. Hashimoto      The 650 km discontinuity as a  
chemical boundary generated by  
partial melting of primitive  
mantle during the accretional  
stage of the earth
- Y. Fukao      Shear wave velocity in the  
mantle transition zone
- D. L. Anderson      Geochemical evolution of the  
mantle
- P. M. Bell  
H. K. Mao      Geophysics of the deep mantle:  
megabar pressure experiments

## High-pressure phase transformations and crystal chemistry

- L. C. Ming  
M. H. Manghnani      High-pressure phase  
transformations in rutile  
structured dioxides
- J. P. Poirier      On the kinetics of olivine-  
spinel transition
- N. Hamaya  
S. Akimoto      Mechanism of olivine-spinel  
transformation: Growth of  
single-crystal spinel in  
single crystal olivine
- H. Sawamoto  
H. Horiuchi  
N. Tokonami  
M. Kumazawa      Single crystal growth of beta  
and gamma (Mg,Fe) SiO<sub>3</sub>  
and their crystallographic  
and optical properties
- H. Horiuchi      Crystal structural studies on  
spinel-related phases and its  
implication to olivine-spinel  
phase transformation
- E. Ito  
Y. Matsui  
H. Yamada      Stability relation of silicate  
ilmenites and perovskites
- C. T. Prewitt      Crystal chemical aspects of phase  
transitions at high pressure

## Crystal chemistry and crystal growth

- P. Shen  
L. Liu  
W. A. Bassett      Disproportionation of  $\text{Fe}_2\text{SiO}_4$   
at high pressure
- H. Watanabe      Thermochemical properties of  
synthesized high-pressure  
minerals relevant to the  
earth's mantle
- A. Navrotsky      Crystal chemical systematics  
derived from calorimetric  
studies of high pressure phases
- R. Jeanloz      Thermodynamic properties across  
phase transitions
- M. Kitamura  
N. Morimoto      Study of the formation mechanism  
of high pressure minerals by  
analytical transmission  
electron microscopy
- Y. Mutsui  
K. Kawamura  
Y. Syono      Molecular dynamic calculation  
applied to silicate melt  
and crystals
- H. Kanda  
O. Fukunaga      Growth of large diamond crystal
- H. Takei  
S. Hosoya  
H. Komatsu  
T. Inoue      Growth and properties of olivine  
single crystals by the  
floating-zone method

## Shock wave experiments

- A. Sawaoka  
K. Kondo  
H. Sugiura      Anomalous compression mechanism  
of fused quartz
- Y. Syono  
T. Goto  
H. Takei      Behavior of single-crystal  
forsterite under dynamic  
compression
- T. J. Ahrens  
G. A. Lyszenga  
M. B. Boslough  
C. T. Creaven      Shock temperature measurements  
in minerals and their  
application to geophysics
- J. N. Fritz  
R. G. McQueen      The Hugoniot equation of state  
of iron oxides

- T. Goto  
J. Sato  
Y. Syono

Shock-induced spin pairing  
transition in  $\text{Fe}_2\text{O}_3$  due to  
the pressure effect on the  
crystal field

- J. M. Brown  
R. G. McQueen

Melting of Fe and FeS under core  
conditions from shock wave data

# HIGH PRESSURE RESEARCH IN JAPAN: AN UPDATE

Earl F. Skelton

## INTRODUCTION

Three years ago, the status of high pressure research in Japan was reviewed by this author through on-site visitations to 43 Japanese high pressure laboratories. The findings of that review were summarized in the first scientific monograph published by ONR Tokyo: "High Pressure Science and Technology in Japan" (ONRT M1). Over the past three years, a considerable number of changes and improvements have taken place in Japanese high pressure research and, at the conclusion of the 2nd U.S.-Japan Seminar on High Pressure Science, at which the author was an invited participant, a tour of five high pressure centers in Japan was offered: the science complex at Tsukuba and the Universities of Kyoto, Nagoya, Osaka, and Tokyo. This provided an excellent opportunity to review the status of this field.

As a preface to this review, it should be noted that today a considerable amount of high pressure research in Japan is being directed or guided on the basis of conclusions reached by the Commission for the Study of Aviation and Electronics Technology. This study was requested by the Ministry of Science and Technology and completed in August, 1980. In the area of general research and development of materials under extreme conditions, the report identified four main areas for consideration: at high pressures, at extremely low temperatures, under ultra high vacuum, and at extremely high temperatures.

Research on materials under conditions of high pressure was subdivided into three categories by the Commission: (1) problems related to the improved development of materials which are known to exist, (2) search for and characterization of new phases of materials, and (3) studies of light elements and compounds under conditions of extremely high pressure, e.g., H<sub>2</sub>, He, and LiH.

In terms of work on known forms of materials (category 1), four areas are considered to be important:

- The application of impulse high pressure techniques (shock) in the processing of power materials,
- The development of ultra hard materials with high thermal conductivities from light elements,
- The development of new superconducting materials, and
- Research on growth techniques for large single crystals.

In the latter category, attention will be focused on diamond, high density BN, and BP. These are all considered to be important as large band-gap semiconductors and it is felt that there is insufficient technology for the development of large, high quality single crystals of these materials. The Commission believes that it is important, for ultimate industrial applications, to be able to produce crystals of 3 to 4 mm dimensions and to simultaneously maintain control over the shape and morphology. Therefore, it has recommended that large volume (100 liter capacity) high pressure generator be developed for growing these crystals by both melt and flux techniques, although initial attention will be focused on smaller volume (1 liter) apparatus.

In the second category, research directed toward new phases of materials will be pursued with the objective of studying the physical properties of the new phases, e.g.,

metallization of molecular phases, specific examples being hydrogen, water, and ammonia. Work will also be carried out in this area on organic materials with similar objectives.

Research in the third category is related to work in fusion and astrophysics; objectives here are directed toward subjecting very light materials (e.g.,  $H_2$ , He, and LiH) to shock pressures in the 100 Mbar range. These pressures are to be produced by accelerating a 1 gm mass to speeds of ca. 50 km/sec prior to impact on the sample target. It is further proposed to study the dense plasma state arising during impact in terms of the pressure, volume (density), and electron temperatures.

Although the report of this Commission is not yet six months old, it was found that some research currently underway in the high pressure laboratories at the aforementioned institutions is already moving along lines proposed in this study and, as noted below, in a few areas, considerable progress has already been realized.

#### TSUKUBA-SCIENCE CITY

Much has been written about the vast research complex at Tsukuba, near Ibaraki, a city which is being methodically constructed by the Japanese government for the purposes of research and education in science and technology. The impact of this community in the area of high pressure research is not insignificant.

Perhaps some of most notable advances in terms of further development of the diamond-anvil pressure cell are currently underway at the National Institute for Researches in Inorganic Materials (NIRIM). One of the most exciting is the very recent fabrication of a pair of supported diamond anvils. Dr. Osamu Shimomura and his coworkers have surrounded the usual gem-type, natural diamond anvils with a structure of synthetic, sintered diamond, which is, in turn, supported by sintered WC (Figure 1). Thus the diamond anvil is completely supported on its lateral surfaces. The entire assemblage is sintered in a single operation after which the upper and lower surfaces are suitably ground and polished. There has not yet been sufficient time to test this new anvil design, but researchers at NIRIM are hopeful that pressures in excess of 100 GPa will be realized.

This same group has also developed a set of plans for a new variable pressure diamond cell designed for operation at cryogenic temperatures. The compressional force between the anvils, and hence the sample pressure, will be varied and controlled through a He-gas/liquid pressure line leading into the cryogenic regions, employing a bellows arrangement, similar to that developed at NRL several years ago.<sup>1</sup> The pressure will be measured *in situ*, by the ruby fluorescence technique, with the laser beam traveling along the central axis of the system. This apparatus is being developed for research on new superconducting materials. It is planned to detect superconducting transitions by using a pair of single winding balanced coils in the manner employed by Kawamura and Tachikawa, also in a diamond-anvil cell, at the nearby National Research Institute for Metals.<sup>2</sup>

Other very recent advances in diamond-cell design made by the group at NIRIM include the design and construction of a new-type of cell for single crystal studies<sup>3</sup> and the introduction of an hydraulic booster for fine control of ultra-high clamped pressures. Work done collaboratively with Professor Minomura's group at The University of Tokyo has led to the introductions of a novel doubly eccentric x-ray collimator system and a position sensitive detector (PSPC) for relating rapid angular dispersive diffraction studies at elevated pressures.<sup>4,5</sup> This latter apparatus was recently used to determine the high pressure structure of Te,<sup>6</sup> following which Raman scattering measurements were carried out on the trigonal phases of both Se and Te.<sup>7</sup> Another very useful discovery made at

NIRIM is the fact that both elevated pressures and temperatures can be simultaneously measured from the shift and broadening of the ruby fluorescence lines.<sup>8</sup>

One of the first extended x-ray absorption fine structure (EXAFS) studies performed under conditions of elevated pressure was carried out by this group on CaAs with the synchrotron radiation source at Stanford University (SSRL).<sup>9</sup> Although that work will be continued later this year, there are also some very exciting EXAFS experiments planned by this group in collaboration with other scientists at Tsukuba. During the past summer at SSRL, Dr. Tadashi Matsushita of the KEK (= Ko Enerugi-butsuri Kenkyusho = High Energy Physics Research Institute, more commonly known in the U.S. as the Japanese "Photon Factory") successfully demonstrated that, by diffracting a broad, polychromatic synchrotron produced x-ray beam from the (111)-surface of a bent Si crystal, the radiation could be spatially separated in terms of its energy and focused through a line approximately 0.6 mm in width. After transmission through a thin sample, the EXAFS pattern spanning a range of about 1 keV around the Cu absorption edge could be recorded in a single measurement.<sup>10</sup> These preliminary experiments were carried out using high speed x-ray film to record the EXAFS pattern, but the follow-on work, planned for this summer with Dr. Hiroyuki Oyanagi of Electrotechnical Laboratory (ETL) at Tsukuba, will be performed with a PSPC to record the EXAFS pattern. The present limitation of this system is the spatial resolution of existing PSPC, viz. about 0.15 mm. In order to obtain the desired energy resolution of about 2 eV (referenced to the Cu absorption edge), it is estimated that a spatial resolution of less than 0.1 mm is required, which is outside the range of existing PSPC detectors. Therefore considerations are currently being given to the possibility of using, instead, photodiodes to convert the x-ray photons to visible light signals. Although this will solve the resolution problem (spatial resolution of the photodiodes are estimated to be about 25  $\mu$ m), it is recognized that there will be a damage problem, caused by the high intensity incident x-ray photons. This problem is currently under consideration.

This same group is also considering the introduction of a modulation technique for future EXAFS studies. The idea is that the angle of attack of the incident crystal of a pair of monochromating crystals would be modulated around the absorption edge of the sample with a PZT transducer at a frequency of about 10 Hz. This would have the effect of modulating the energy of the photons passed by the monochromator and would thereby allow measurement of the second-derivative of the EXAFS spectrum in the vicinity of the absorption edge. This is an extension of the ideas originally introduced by Shevchik for frequency modulated x-ray diffraction<sup>11</sup> and should, *inter alia*, permit a much more accurate determination of background corrections in analyses of EXAFS spectra. A block diagram of the system as envisaged by Dr. Oyanagi is shown in Figure 2.

An example of the degree of sophistication which is being brought to bear on problems in materials research at Tsukuba is provided by Dr. Hideo Ihara and his co-workers at ETL. They are involved in various techniques aimed at the development of materials with superior superconducting properties. As a preface to their work, they have compiled a vast data bank based on published data of "every superconductive material and related non-superconductive material."<sup>12</sup> Among the recorded properties are: crystal structure, lattice parameters, critical temperature and field ( $T_c$  and  $H_c$ ), Debye temperature, electronic specific heat, and electronic density of states. This data bank can then be accessed to test various empirical rules appertaining to the prediction of high  $T_c$  materials. For example, Dr. Ihara points out that Matthias' rule, which predicts a relationship between  $T_c$  and the number of valence electrons per atom, while it appears to hold well for Al<sub>5</sub>-type structures, and reasonably well for B1-type structures, is rather poor when applied to all known superconducting materials.

Perhaps of even greater interest is the prediction of calculations by Dr. Ihara *et al.*<sup>12</sup> of a  $T_c$  of 30K for  $NbC_xN_{1-x}$  as  $x \rightarrow 0$  based on the McMillan equation. This group is also preparing  $NbC_xN_{1-x}$  compounds by sputtering techniques and has recently improved their maximum  $T_c$  of NbN from 15 to 17.8K. Dr. Ihara believes the 12.2K difference between their prediction and best sample to date is due to the presence of N-vacancies. They are currently trying super rapid quenching techniques to solve this problem.

Indeed, there is a good amount of very high quality research currently underway at Tsukuba, and the work planned for the immediate future promises to be equally exciting. It is expected that next year, when the synchrotron radiation source ("Photon Factory") becomes operational at Tsukuba, this important research tool will also be brought to bear on high pressure and related materials research problems in Japan.

#### UNIVERSITIES OF KYOTO, NAGOYA, OSAKA, AND TOKYO

Recent high pressure studies at Kyoto University include fracture and deformation analyses of silicate rocks; specifically, granite, basalt, and dunite were fractured at pressures up to 3 GPa. The granite and dunite were brittlely fractured, whereas the basalt became somewhat ductile at about 0.3 GPa. This work represents part of a continuing study on the mechanical properties of porous rocks which is being pursued at Kyoto University with the ultimate objectives of learning more about the earth's lower crust and upper mantle.

Perhaps one of the most impressive research tools recently set up at Nagoya University (NU) is a super intense rotating anode x-ray generator, said to be the most intense x-ray source of its kind in the world. By sealing the x-ray targets in a ultra high vacuum environment [ca.  $(1.4-2.5) \times 10^{-7}$  Torr], electron currents in the ampere range can be maintained at operating potentials of ca. 60 kV. A recent limit of 41 hours operation was achieved at operating condition of 1.4 amps & 55 kV with a Cu target. This beam power of 77 kW is well above that available, even from a commercial rotating anode unit. The anode itself is run at 10,000 revolutions per minute and has a spot size of 10 mm x 1 mm. The apparatus is presently being used for x-ray topography studies, observations of *in situ* crystal growth of benzile, and fundamental analyses of the structure factor of Si.

The largest piece of high pressure apparatus at NU is the 10,000 ton press operated by Professor Kumazawa and his group. Three years ago this equipment was just being installed, now it is fully operational and the staff estimates that on the average six high pressure runs are completed per week. They are also quick to point out, however, that considerable use continues to be made of the smaller 2000 ton press at NU, where studies are being pursued on various iron silicates ( $Fe_2SiO_5$ ; e.g., fayalite, spinel, and ferrosillite) and magnesium silicates.

Despite the unfortunate loss of Professor Kawai, high pressure research continues to be a high priority item at Osaka University (OU). The largest uniaxial press in Japan (15,000 tons) is still a principal focal point of attention. In addition to fundamental research on materials, this system has been recently used for sintering of superhard diamond compacts for future use as anvil materials. Recent basic research includes studies of the electrical resistance of  $\alpha$ - $Fe_3C$ ,<sup>13</sup> up to 50 GPa, of the phase diagrams of ice,<sup>14</sup> and of Ba, and Bi.<sup>15</sup>

Professor Onodera and his co-workers have recently equipped their cubic press with

x-ray diffraction attachments and are presently involved in equation of state studies. Very current work completed by this group includes studies of several semisintered oxides in terms of efficiency as pressure transmitting media<sup>16</sup> and the pressure dependence of their shear strength.<sup>17</sup> The purpose of these studies is to find a possible replacement medium for pyrophyllite, a commonly used pressure transmitting substance which tends to decompose at pressures above 10 GPa and at elevated temperatures.

This group has also completed some very important studies of fixed point pressure calibration standards.<sup>18,19</sup> By performing simultaneous *in situ* measurements of the volume of NaCl and the electrical resistance of four calibrant materials (ZnTe, ZnS, GaAs, and GaP) with four different pressure transmitting media (amorphous boron, diamond, graphite-type BN, and LiH), they have found that transitions observed with less hydrostatic media, e.g., diamond, tend to occur at lower pressures, as compared to a more hydrostatic environment. For example, based on the compression of NaCl and its accepted equation of state, the phase transition in GaP is observed at  $22.0 \pm 0.9$  GPa in a diamond medium, but at  $25.3 \pm 1.0$  GPa in a boron medium.

High pressure research at Tokyo University (TU) may still be found on both the main campus as well as the Institute for Solid State Physics (ISSP) near Roppongi. Recent work at the Geophysical Institute relates to studies of crack propagation and the fracture strength of rocks,<sup>20</sup> the effect of water on growth of cracks in silicate rocks,<sup>21</sup> and analyses of the relationship between fracture strength of rocks and the zeta-potential.<sup>22</sup>

At the ISSP, high pressure research continues to be pursued more or less independently by two research groups; those under Professor Akimoto and those under Professor Minomura. In the former group, Drs. T. Yagi and N. Hamaya have made considerable progress in further development of the diamond anvil cell. (Dr. Yagi has recently returned from a research year at the Carnegie Geophysical Laboratory in Washington, D.C.) One of their notable improvements has been the development of a conical receiving aperture for use with a solid state x-ray detector which, when used with a rotating anode x-ray source at 9 kW, permits the accumulation of adequate scattering data in exposures of 1000 sec. Pressures up to 60 GPa are reported in a recent study of  $\alpha\text{-Fe}_2\text{O}_3$ . This facility ideally compliments the larger volume cubic presses which have been operational here for some time.

As noted above, some of Professor Minomura's work has been done in collaboration with scientists now at Tsukuba. Details of developments with the position sensitive detection system have recently been discussed in the literature.<sup>23</sup> Some of Professor Minomura's current research interests are focused on amorphous semiconductors.

#### CONCLUSIONS:

To summarize the differences seen between the Japanese high pressure research community today with those observed three years ago is not a simple task. Among other reasons, the previous survey was conducted over a much larger time base (almost four months) which naturally permitted a considerably broader scientific scope of analysis. The current review was completed within a few days and was focused principally, although not exclusively, in areas of geophysical interest. However, based on the observations which have been made, it appears that there are several instances where one might consider that a reasonable amount of progress has been made over the intervening three years. There were also one or two groups who seemed to be doing more or less the same things that were underway before. At the other extreme, there were also groups, e.g., at the University of Tokyo and at Tsukuba, where significant progress appears to have been made. It appeared

to this observer that there is neither a shortage of creativity, enthusiasm, nor research funds at the new "Science City." This appears to be a very exciting and stimulating environment for any scientist to carry out research - Japanese or foreign. Perhaps the only drawback might be that associated with such total immersion into a completely homogeneous society of scientists and technical types, "Man does not live by bread alone," and perhaps periodic departures into a more heterogeneous community might be welcomed from time to time. It is, however, the opinion of this observer that many significant scientific papers coming out of Japan in years to come will have the name "Ibaraki" on the title page.

As indicated at the beginning of this report, there appears to be a considerable amount of national direction to research in the field of high pressure science in Japan and although there has perhaps been insufficient time to adequately assess the impact of this method of guiding research, the initial signs, as detected by this observer, would appear to be positive. It was learned, e.g., that there is a team of high pressure scientists coming from four or five different laboratories throughout Japan, all collaborating on the development of new high  $T_c$  superconducting materials-such a program appears, again, in the eyes of this observer, to be a very wholesome and promising arrangement.

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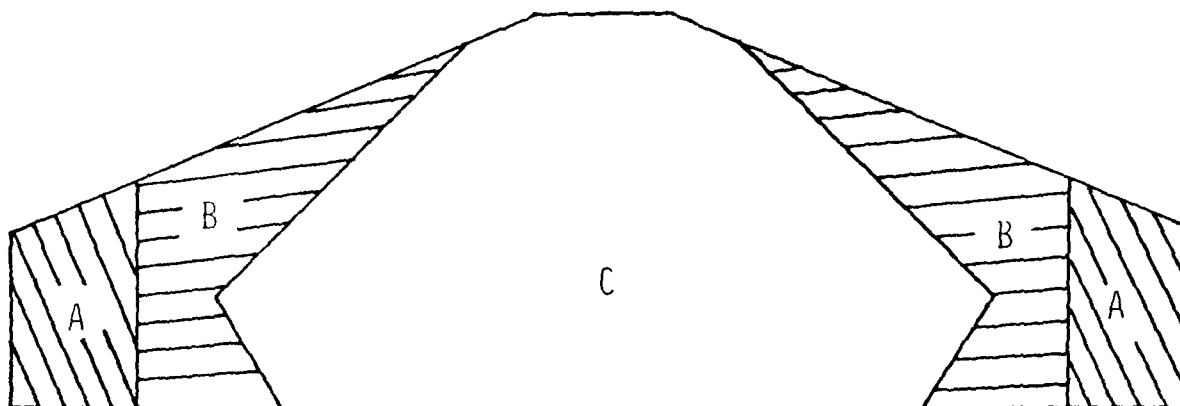


Fig. 1. Supported Diamond Anvil. The normal gem-type natural diamond anvil is totally supported on its lateral surfaces by sintered synthetic diamond, which is, in turn, supported by a sintered WC-structure.

A: sintered WC, B: sintered synthetic diamond, C: gem-type natured diamond

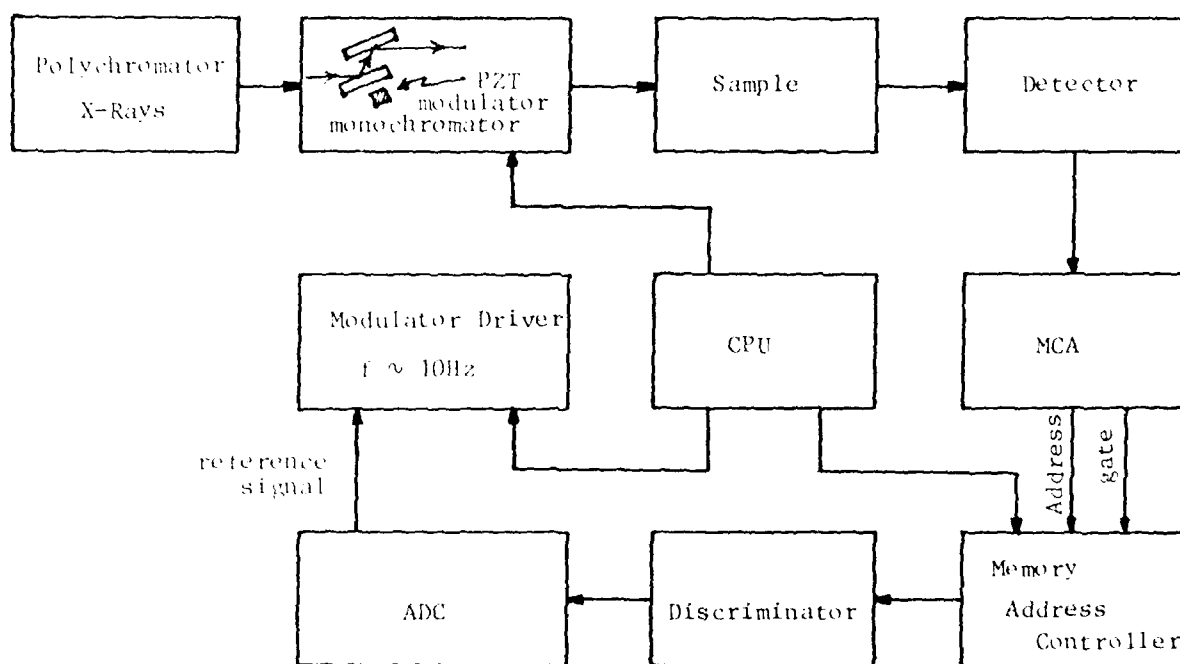


Fig. 2. Block diagram for modulation of the incident photon energy around the absorption edge energy for measurement of second derivative EXAFS spectra, as envisaged by H. Oyanagi.

INFORMAL REPORT ON THE CONFERENCE ON THE DESIGN OF  
MOLECULAR STRUCTURES:  
MOLECULAR SYSTEMS FOR ELECTRONIC DEVICES

William A. Little

A conference on the design of molecular structures, "Molecular Systems for Electronic Devices," was held at the Institute of Molecular Science, Okazaki, Japan, 26-29 November, 1980.

This was part of a U.S.-Japan cooperative research program between Professor H. Kuroda (Department of Chemistry, Tokyo University), and Professor W. A. Little (Department of Physics, Stanford University). The meeting was sponsored partly by the Institute of Molecular Science, the Japanese Society for the Promotion of Science, and the U.S. National Science Foundation.

The overall purpose of the cooperative research program is to focus attention on the scientific problems associated with the design of structures of molecules-not the design of the structure of molecules, which is the major concern of organic chemistry, but rather the design of structures composed of complex organic molecules. Special attention is being directed to systems such as, organic metals and superconductors, time-temperature indicators, artificial muscles, and molecular memory devices. The conference at Okazaki was attended by six U.S. participants, representing both industry and universities, and 38 Japanese participants from universities, industry and the Institute of Molecular Science.

The meeting was opened by an address by Professor H. Akamatsu, Director General of the Institute. He set the scene by stressing the cooperative role that clusters of molecules play in determining the physical and chemical properties of a compound. He pointed out that "organic" compounds derive their name not simply from the fact that they are compounds made of carbon, but rather that the term meant, originally, substances which make up an organism. In essence, the utilization of this molecular organism was the focus of the meeting.

Professor W. A. Little (Stanford) gave an overview of the aims of the program, illustrating the role of molecular aggregates in determining the properties of organic metals and superconductors, enzymes, solvent sensitive dyes, and contractile polymers. He also described briefly the progress on the cooperative program involving the development of a microminiature refrigerator for a microspectrophotometer cold stage, done in collaboration with Professor H. Kuroda and Dr. K. Yakushi of Tokyo University. The miniature device has application in x-ray analysis, electronmicroscopy, infrared detectors, and solid state research.

Dr. Y. Matsunaga (Hokkaido University) described work on the systematic design of liquid crystals from the study of the phase diagram of binary solutions. Dr. H. Mikawa (Osaka University) reported on the sensitization and technical use of organic photoconductors. An extremely interesting presentation and film was given by Dr. R. Baughman (Allied Chemical) on the utilization of the polymerization of diacetylenes as time-temperature indicators. These integrate the temperature history of the activation process of polymerization, giving a sharply defined color change upon completion. These systems can be designed to match the spoilage rate of vaccines, foods, or photographic materials. The utilization of these devices was beautifully shown in a short film. R. Wolfe (Stanford University) described preliminary work on a physical technique involving the activated diffusion of a compound through a precisely controlled barrier layer to achieve the same end.

Dr. A. Aviram (IBM) spoke on the successful design of contractile polymers whose dimensions and shape could be changed by photochemical or electrochemical means. The striking feature of these systems is that the fractional contraction achievable is of the order of 0.5 as compared to electrostrictive or magnetostrictive devices, where it is of the order of  $10^{-4}$ - $10^{-5}$ .

Professor I. Tanaka (Nagoya University) gave an interesting presentation on intermolecular charge transfer resonance of molecular crystals. This served also to open a session on the optical and conductive properties of organic metals. Professor H. Kuroda (Tokyo University) gave an elegant review of the utilization of optical studies to determine the properties of organic metals. Dr. B. Street (IBM) brought the meeting up to date with the rapidly evolving field of conductive, doped polymers including  $(\text{SN})_x$ ,  $(\text{CH})_x$  polyphenylene sulphide and polypyrrole. Dr. R. Baughman (Allied Chemical) gave a different but penetrating view of the same field. This session was concluded by Dr. Inokuchi (Institute of Molecular Science) who described the remarkable conductive properties of certain biological systems particularly Cytochrome C3 and their sensitivity to the presence and pressure of hydrogen. These systems continue to present a challenge to our understanding and a goal for the design and synthesis of novel materials.

On the final day two applications were discussed, one on electrical switching in Cu-TCNQ thin films by Dr. R. Potember (Johns Hopkins University) and the other by Dr. S. Yoshimura (Matsushita Research Institute) on thermal delay devices, using organic charge transfer complexes. Promising results were reported in both cases.

The conference, in addition to providing a place and focus for the formal presentation of papers, also provided a place for the discussion of more general questions on the exchange of ideas and technology; and, of making personal contacts between representatives of the two countries. The latter was fostered by a relaxed evening schedule, allowing the U.S. contingent to sample and enjoy Japanese cuisine and culture with the help and guidance of their hosts. A return meeting is scheduled to be held in the U.S. at Stanford University in August 1981.

## APPENDIX I

Mailing addresses of principal investigators mentioned in this article:

- Tokyo University  
Department of Chemistry  
Faculty of Science  
3-1, Hongo 7chome  
Bunkyo-ku, Tokyo 113  
Professor Haruo Kuroda  
Dr. Kyuya Yakushi
- Hokkaido University  
Department of Chemistry  
Faculty of Science  
Nishi-8chome, Kita 10-jo  
Kita-ku, Sapporo, Hokkaido 060  
Professor Yoshio Matsunaga
- Nagoya University  
Furo-cho, Chikusa-ku  
Nagoya, Aichi 464  
Professor I. Tanaka
- Allied Chemical Corp.  
P.O. Box 1087R Morristown  
NJ 07960, U.S.A.  
Dr. R. Baughman
- Hiroshima University  
Faculty of Engineering  
8-2, Senda-cho 3-chome  
Hiroshima 730  
Professor Ryogo Hirota
- Kyushu University  
Faculty of Science  
10-1, Hakozaki 6-chome  
Higashi-ku, Fukuoka 812  
Associate Prof. Kenji Kobayashi
- University of Tokyo  
Institute for Solid State  
Physics  
22-1, Roppongi 7-chome  
Minato-ku, 106, Tokyo  
Professor Kinshiro Hirakawa
- Institute of Molecular Science  
38, Nishigo-naka, Myodaiji-cho  
Osazaki, Aichi 444  
President, Professor Hideo Akamatsu  
Professor Hiroo Inokuchi
- Osaka University  
Faculty of Engineering  
Yamada-ue, Suita, Osaka 565  
Professor H. Mikawa
- Matsushita Research Institute  
4896, Ikuta, Tama-ku  
Kawasaki, Kanagawa 214  
Dr. S. Yoshimura
- Stanford University  
Department of Physics  
Stanford, CA 94305, U.S.A.  
Professor W.A. Little  
R. Wolfe
- Kyoto University  
Faculty of Science  
Oiwake-cho, Kitashirakawa  
Sakyo-ku, Kyoto 606  
Dr. Michio Jimbo  
Dr. Tetsuji Miwa
- Tohoku University  
Department of Physics  
Faculty of Science  
Aoba, Aramaki, Sendai  
Miyagi 980
- Hokkaido University  
Faculty of Science  
Nishi 8-chome, Kita 10-jo  
Kita-ku, Sapporo, Hokkaido 060  
Associate Prof. Hajime Takayama

- University of Tokyo  
Department of Physics  
Faculty of Science  
3-1, Hongo 7-chome  
Bunkyo-ku, Tokyo 113  
Associate Professor Yasushi Wada

## INFORMAL REPORT ON THE SOLITON CONFERENCE IN JAPAN

Kazumi Maki

I attended a Conference on Solitons in Condensed Matter Physics held at Tsukuba Center, Japan, 4-5 December, 1980. I also had, on my way to the conference, a chance to visit several institutions in Kyoto, Tokyo, and Tsukuba to discuss the soliton-related problems with Japanese physicists. The following is my impression of the conferences, as well as the activity in this field in Japan.

The contributions to the conference, titles, and authors, are given below:

- "Recent progress in nonlinear wave theories," Ryogo Hirota of University of Hiroshima,
- "Holonomic quantum fields," Michio Jimbo and Tetsuji Miwa, RIMS, Kyoto University,
- "Quantum theory of solitons," Miki Wadati, University of Tokyo,
- "Soliton solutions of nonlinear wave equations in higher space dimensions," Kenji Kobayashi, Kyushu University,
- "Solitons in systems with multi-component order parameters-superfluid  $^3\text{He}$ ," Hiromichi Ebisawa, Tohoku University,
- "Solitons in low dimensional magnetic systems - neutron scattering experiments," Kinshiro Hirakawa, ISSP, University of Tokyo,
- "Quantum statistic of solitons," Hajime Takayama, Hokkaido University,
- "Correlation functions in quasi-one-dimensional systems," Kazumi Maki, University of Southern California,
- "Dynamics of domain walls," Yasushi Wada, University of Tokyo,
- "Solitons in dimerized systems," Hidetoshi Fukuyama, ISSP, University of Tokyo.

Hirota classified a variety of complete integral systems, making use of the bilinear form, while Miwa presented a well-known work of Sato-Jimbo-Miwa, which transforms the problem of calculating the two point correlation function into that of solving the boundary value problem of the Painleve type equation.

Wadati described the treatment of the transfer matrix due to Fedeev and its relation to the Bethe ansatz. Kobayashi showed slides of numerical solutions for the ionic wave in plasma in two space dimension and the two dimensional sine-Gordon equation and Ebisawa talked on the method of homotopy developed by Volovick and Mineev.

Hirakawa gave a beautiful review on the experimental work done on  $\text{CsNiF}_3$  (1D-planar ferromagnet in magnetic fields), TMMC (1D-planar antiferromagnet in magnetic fields), and  $\text{CsCoCl}_3$  (1D-Ising like antiferromagnet), including some of his own work done in Japan.

Takayama and I reported on the work we had done together while Takayama was visiting USC. Wada reported on his work with J. R. Schrieffer, and further development on this work as well.

Finally, Fukuyama presented an alternative model for solitons in polyacetylene to the model of Su, Schrieffer, and Heeger.

In addition to these invited talks, there were several interesting short reports worth mentioning. For example, N. Suzuki (University of Osaka) presented his work on the optical absorption spectra of lightly doped polyacetylene (*Phys. Rev. Lett.* 45, 1209, 1980), and N. Kinoshita (Electronic Technical Lab) reported ESR measurement of pristine and lightly doped polyacetylene. Kinoshita discovered that at  $T = 0.1$  K, the width of ESR line is still being controlled by the motional narrowing corresponding to the average soliton velocity of  $v \sim 80$  m/sec.

In general, Japanese workers are strong in formal analysis and have made important contributions in the mathematical side of soliton physics. On the other hand, the experimental side appears to lag somewhat behind. Furthermore, both theorists and experimentalists suffer from lack of mutual communication, although there are now many good theorists, as well as experimentalists, in Japan.

The university complex at Tsukuba is quite impressive in its spatial extension and its tall, solid buildings. I have heard that KEK (laboratory for high energy physics) is functioning quite well. However, I have the feeling that we will have to wait some time before we see real blossoming of the scientific activities in this vast, and somewhat, desolate complex. The complex may be comparable in its dimension to Los Alamos or Brookhaven National Laboratory in the U.S.

# INTERNATIONAL MEETINGS IN THE FAR EAST

1981-1983

Compiled by Seikoh Sakiyama

It is intended to update and augment this list in future issues of the Scientific Bulletin. The assistance of Dr. T. D. Grace, Australian Embassy, Tokyo, and Dr. M. J. McNamara, New Zealand Embassy, Tokyo, in supplying a listing of meetings in their countries is deeply appreciated. Similarly, the assistance of Dr. Robert Stella, American Embassy, New Delhi (formerly in Seoul), in supplying a listing of meetings in Korea is deeply appreciated. Readers are asked to notify us of upcoming international meetings in the Far East which have not yet been included in this list.

1981

Date	Title	Site	For information, contact
April 13-17	International Telecommunications Conference	New Zealand	NZ Post Office Wellington
April 26-May 1	1st Asian and Pacific Chemistry Congress	Singapore, Republic of Singapore	The Congress Secretary 1st Aspac Congress Singapore Professional Center 129B Block 23 Ontram Park Singapore 0316 Republic of Singapore
May 4-8	Annual Scientific Meeting of the Australian Society Microbiology	Canberra, Australia	V. A. Stanisich, Australian Society for Microbiology 191 Royal Parade Parkville, Vic, 3052
May 11-14	12th Australian Polymer Symposium	Blackheath, Australia	D. F. Sangster, AAECRE Private Mail Bag Sutherland, NSW, 2232
May 11-15	4th International Symposium on Trace Element Metabolism in Man & Animals (TEMA-4)	Perth, Australia	Dr. E.J. Underwood Chairman Organising Committee TEMA-4, c/o Dept of Animal Science University of WA Nedlands, WA, 6009
May 11-15	Australian Biochemical Society Annual Meeting	Adelaide, Australia	Dr. H.C. Robinson Dept. of Biochemistry Monash University, Clayton Vic, 3168

1981, continued

Date	Title	Site	For information, contact
May 13-15	3rd International Congress on Polymers in Concrete	Fukushima, Japan	3rd International Congress Polymers in Concrete Dept. of Technology Nihon University Tamuracho, Koriyama-shi Fukushima 963
May 18-22	4th International Coral Reef Symposium	Manila, Philippines	Marine Sciences Center IV CRS University of the Philippines PO Box 1, Diliman Quezon City 3004
May 23-30	The 12th Conference of the International Association of Ports and Harbors	Nagoya, Japan	Nagoya Port Authority 1-8-21, Irifune, Minato-ku Nagoya 455
May 25-29	International Tsunami Symposium 1981	Sendai, Japan	Prof. E. Kajiura Earthquake Research Institute University of Tokyo 1-1, Yayoi 1-chome Bunkyo-ku, Tokyo 113
May (tentative)	34th Annual Metals Congress	Sydney, Australia	(Undecided)
May (tentative)	Electric Energy Manufacturing Conference	(undecided) Australia	The Institution of Engineers, Australia 11 National Circuit Barton, ACT, 2600
June 6-7	The 4th International Symposium on Quality Control-Osaka	Kobe, Japan	Secretariat, ISQC-Osaka Kobe Minato PO Box 569 Hyogo 651-01
June (tentative)	ROK-ROC Seminar on Oceanography	Seoul, Korea	Korea Ocean Research and Development Institute PO Box 17, Yang-Jae, Seoul
June 26-July 3	5th International Conference on Geochronology Cosmochronology and Isotope Geology	Nikko, Japan	Dr. K. Shibata Geological Survey of Japan 1-1-3, Yatabe-cho Higashi Tsukuba-gun, Ibaraki 305

1981, continued

Date	Title	Site	For information, contact
June 29-July 3	The VIIth International Symposium on Gnotobiology	Tokyo, Japan	Prof. S. Sasaki Chairman, Organizing Committee VII International Symposium on Gnotobiology Dept. of Microbiology School of Medicine Tokai University Bohseidai, Isehara-shi Kanazawa 259-11
June 19-24	8th International Congress of Pharmacology -IUPHAR-	Tokyo, Japan	The Japanese Pharmacological Society Gatsukai Center Bldg. 4F 2-4-16, Yayoi, Bunkyo-ku Tokyo 113
July	International Conference on Thermodynamics and Kinetics of Metallurgical Processes	Bangalore, India	Dr. G.N.K. Iyengar ICMS 81 Department of Metallurgy Indian Institute of Science Bangalore 560012
July 27-August 1	The 4th International Congress of Biorheology	Tokyo, Japan	Japanese Society of Biorheology Physics Laboratory Keio University 4-1-1, Hiyoshi Kohoku-ku, Yokohama 223
August 10-14	International Congress of Pharmacology	Sydney, Australia	Australian Academy of Science PO Box 783, Canberra City ACT. 2601
August 17-21	21st Conference on Physical Sciences & Engineering in Medicine and Biology	Melbourne, Australia	Mr. K.H. Clarke Dept. of Physical Sciences Cancer Institute 481 Little, Lonsdale St. Melbourne, Vic, 3000
August 18-21	2nd Biennial Conference and Exhibition of the Australian Society of Exploration Geophysicists	Adelaide, Australia	Dr. J. Haigh PO Box 42, Unley South Australia 5061

1981, continued

Date	Title	Site	For information, contact
August 21-28	XIII International Botanical Congress	Sydney, Australia	Executive Secretary Dr. W.J. Cram School of Biological Sciences University of Sydney N.S.W., 2006
August 23-28	6th Australian Symposium on Analytical Chemistry (6AC)	Canberra, Australia	Hon. Secretary Miss B. J. Stevenson PO Box 1397, Canberra City ACT, 2601
August 24-26	Vth International Conference of Electrical Bio-impedance	Tokyo, Japan	Prof. K. Nakayama Dept. of Electrical & Engineering Sophia University 7 Kioicho, Chiyoda-ku Tokyo 102
August 24-28	4th International Conference on Rapidly Quenched Metals	Sendai, Japan	The Japan Institute of Metals Aramaki Aoba Sendai, Miyagi 980
August 24-28	International Federation of Automatic Control (IFA) 8th Triennial World Congress	Kyoto, Japan	Prof. Y. Sawaragi Dept of Applied Mathematics and Physics Faculty of Engineering Kyoto University Yoshida-Honmachi Sakyo-ku, Kyoto 606
August 25-28	International Conference on Computing for Development	Bangkok, Thailand	Dr. Kanchit Malaivongs ICCD Secretary, Asian Institute of Technology PO Box 2754, Bangkok
August 26-27	Symposium on Stress Analysis for Mechanical Design 1981	Sydney, Australia	The Conference Manager Institution of Engineers Australia 11 National Circuit Barton, ACT, 2600
August 31-September 5	IACEI Symposium on ARC Volcanism	Hakone, Japan	Volcanological Society of Japan Earthquake Research Institute University of Tokyo 1-1-1, Hongo, Bunkyo-ku, Tokyo 113

1981, continued

Date	Title	Site	For information, contact
September 4-5	'81 Kobe International Symposium on Aging	Kobe, Japan	Dr. S. Yoshida Japan WHO Association Kyoto Shoko-kaigi Bldg. Karasuma-dori Ebisugawa-agaru, Nakagyo-ku Kyoto-shi, Kyoto 604
September 4-8	9th ICAS-XXII CSI (9th International Conference on Atomic Spectroscopy and XXII Colloquium Spectroscopium Internationale)	Tokyo, Japan	The Japan Society for Analytical Chemistry 9th ICAS-XXII CSI Gotanda-Sannaitsu 26-2, 1-chome Nishi-gotanda, Shinagawa-ku Tokyo 141
September 6-18	XVIIth IUFRO (International Union of Forestry Research Organization) World Congress	Kyoto, Japan	Government Forestry Experiment Station The Ministry of Agriculture Forestry and Fisheries 1 Matsunosato Kukizaki-mura, Inasniki-gun Ibaraki 300-12
September 13-18	The 10th International Congress of Electroencephalography and Clinical Neurophysiology	Kyoto, (undecided) Japan	International Conference Organizers, Inc. Crescent Plaza 103, 2-4-6 Minami-Aoyama, Minato-ku Tokyo 107
September 17-21	The 14th World Congress of International League against Epilepsy and the 13th Symposium of the International Bureau for Epilepsy	Kyoto, Japan	International Conference Organizers, Inc. Crescent Plaza 103, 2-4-6 Minami-Aoyama, Minato-ku Tokyo 107
September 20-23	1981 International Symposium on Gallium Arsenide and Related Compounds	Kanazawa, Japan	Prof. H. Yanai Dept. of Electronic Engineering University of Tokyo 7-3-1, Hongo Bunkyo-ku, Tokyo 113
September 29-25	12th world Congress of Neurology	Kyoto, Japan	Simul International, Inc. No.9, Kowa Bldg., 1-8-10 Akasaka, Minato-ku Tokyo 107

1981, continued

Date	Title	Site	For information, contact
September 21-24	International Rock Mechanics Symposium on Weak Rock -Soft, Fractured and Weathered Rock- (ISRM)	Tokyo, Japan	Japan Society of Civil Engineers 1-chome, Yotsuya Shinjuku-ku, Tokyo 160
September 21-25	The Vith International Symposium on Glycoconjugates	Tokyo, Japan	Prof. T. Osawa, Division of Chemical Toxicology and Immunochemistry Department of Pharmacy University of Tokyo 7-3-1 Hongo, Bunkyo-ku Tokyo 113
September 21-26	3rd International Con- ference on Environmental Mutagens	Tokyo, Japan	The Third Int'l Conference Mutagens PO Box 236, Kyobashi Tokyo 104-91
September 23-25	Australian Society of Nephrology joint meeting with Cardiac Society	Brisbane, Australia	Dr. B. M. Saker Renal Unit, Royal Perth Hospital, Perth, WA 6000
September 28-30	International Symposium on Powder Technology '81	Kyoto, Japan	The Society of Powder Technology, Japan Shibunkaku Kaikan Sekidencho, Tanaka Sakyo-ku, Kyoto 606
October 4-7	4th Congress of Inter- national Society for Laser Surgery	Tokyo, Japan	Narong Nimsakul, M.D., Secretary General 4th Congress of Inter- national Society for Laser Surgery Dept. of Plastic Surgery School of Medicine Tokai University Boseidai, Ischara-shi Kanagawa Pref. 259-11
October 7-9	11th International Sym- posium on Industrial Robots (and Robot Exhibit)	Tokyo, Japan	Mr. Y. Komori Japan Industrial Robot Association Kikai Shinko Bldg. 3-5-8, Shiba-koen Minato-ku, Tokyo 105

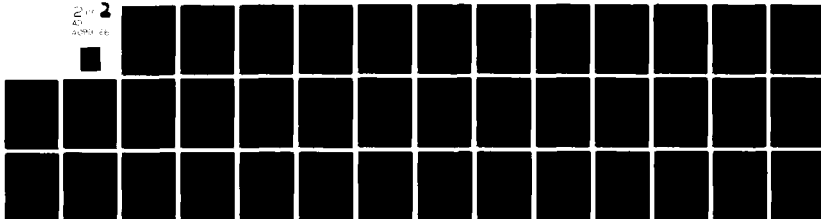
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1981, continued

Date	Title		For information, contact
October 9-10	2nd International Symposium on Endocrinology in Anesthesia & Surgery	Kyushu, Japan	Prof. T. Oyama Dept. of Anesthesiology School of Medicine University of Hirosaki Hirosaki-shi, Aomori 036
October 11-23	International Union Conservation of Nature	Christchurch, New Zealand	Lincoln College, Christchurch
October 18-25	15th Annual Conference on Law of the Sea	Seoul, Korea	Korea Ocean Research and Development Institute PO Box 17, Yang-Jae, Seoul
October 26-30	FAI the 74th General Conference, 1981 (International Aeronautical Federation)	Tokyo, Japan	Japan Aeronautic Association 1-18-2, Shinbashi Minato-ku, Tokyo 107
October/ November (tentative)	Seminar on Estuaries-their Physics, Chemistry, Biology, Geology and Engineering Aspects	Goa, India	Dr. R. Sen Gupta Convener, Seminar on Estuaries National Institute of Oceanography Dona Poul, Goa-403004
December (tentative)	Ninth International Symposium on Comparative Endocrinology	Hong Kong	Prof. B. Lofts Dept. of Zoology The University of Hong Kong

1982

Date	Title	Site	For information, contact
February (tentative)	7th Australian Electron Microscopy Conference	Canberra, Australia	Australian Academy of Science PO Box 783, Canberra City ACT, 2600
April/May (tentative)	Second International Workshop on the Malacofauna of Hong Kong and south China	Hong Kong	Dr. B.S. Morton Department of Zoology The University of Hong Kong
May 10-14	Annual Scientific Meeting of the Australian Society for Microbiology	Hobart, Australia	Dr. J. Bould Baas Becking Laboratories PO Box 378, Canberra City ACT, 2601

1982, continued

Date	Title	Site	For information, contact
May 10-15	General Meeting of the International Association of Geodesy	Tokyo, Japan	Assistant Prof. I. Nakagawa Geophysical Institute Faculty of Science Kyoto University Oiwake-cho, Kita-Shirakawa Sakyo-ku, Kyoto 606
May 11-14	International Cryogenics Engineering Conference	Kobe, Japan	Prof. H. Nagano The Institute for Solid State Physics University of Tokyo 7-22-1 Roppongi, Minato-ku Tokyo 106
May 17-20	The 3rd World Conference on Lung Cancer	Tokyo, Japan	S.G. Prof. K. Suematsu The Secretariat of the 3rd World Conference on Lung Cancer National Cancer Center 5-1-1 Tsukiji, Chuo-ku Tokyo 104
May 23-28	16th International Congress of Dermatology (CID)	Tokyo, Japan	Japan Convention Service, Inc. Nippon Press Center 8F 2-2-1, Uchisaiwai-cho Chiyoda-ku, Tokyo 100
May (tentative)	35th Annual Metals Congress	Sydney, Australia	Australasian Institute of Metals PO Box 263, Bondi Beach NSW, 2026
June 7-11	9th International Congress on Electrocardiology (23rd International Symposium on Vectorcardiography)	Tokyo, Japan	Tokyo University School of Medicine 7-3-1 Hongo, Bunkyo-ku Tokyo 113
June 7-11	4th International Symposium on the Genetics of Industrial Microorganisms	Kyoto, Japan	GIM Japan National Committee Microbiology Research Foundation 2-4-16 Yayoi, Bunkyo-ku Tokyo 113

1982, continued

Date	Title	Site	For information, contact
June 27- July 2	5th International Conference on Geochronology, Cosmochronology & Isotope Geology	Nikko, Japan	Geological Survey of Japan Agency of Industrial Science and Technology 1-1-3 Yatabe-Higashi Tsukuba-Gun, Ibaraki 305
June (tentative)	12th International Conference of Biochemistry	Sydney, Australia	Prof. W.H. Elliot Biochemistry Department University of Adelaide Adelaide, S.A. 5000
July 5-10	VI International Symposium on Solute-Solute-Solvent Interactions	Osaka, Japan	Prof. H. Ohtaki Tokyo Institute of Technology at Nagatsuta Dept. of Electronic Chemistry Nagatsuta, Midori-ku Yokohama 227
Mid-July (tentative)	The 5th International Congress of Plant Tissue	Yamanashi, Japan	Assistant Prof. A. Komamine Dept. of Botany Faculty of Science University of Tokyo 7-3-1, Hongo, Bunkyo-ku Tokyo 113
August 15-21	International Biochemical Congress	Perth, Australia	Australian Academy of Science and International Union of Biochemistry PO Box 783, Canberra ACT, 2601
August 22-26	The 7th Asia and Oceania Congress of Endocrinology	Tokyo, Japan	Prof. K. Shizume Dept. of Medicine 2 Tokyo Women's Medical College Kawadacho, Shinjuku-ku Tokyo 162
August 22-27	4th International Conference on Organic Synthesis (IUPAC)	Tokyo, Japan	Prof. T. Mukaiyama Dept. of Chemistry Faculty of Science University of Tokyo 7-3-1, Hongo, Bunkyo-ku Tokyo 113

1982, continued

Date	Title	Site	For information, contact
August 29- September 4	The 5th International Congress of Pesticide Chemistry, IUPAC	Kyoto, Japan	Rikagaku Kenkyusho (The Institute of Physical and Chemical Research) 2-1 Hirosawa, Wako-shi Saitama 351
August (tentative)	The Royal Australian Chemical Institute 7th National Convention	Canberra, Australia	Executive Secretary, RACI HQ 191 Royal Parade Parkville, Vic. 3052
August (tentative)	13th Australian Spectroscopy Conference	(undecided) Australia	Australian Academy of Science PO Box 783, Canberra City ACT, 2601
August (tentative)	1982 International Conference on Solid State Devices	Tokyo, Japan	The Japan Society of Applied Physics Kikai-Shinko-Kaikan 5-8, 3-chome, Shibakoen Minato-ku, Tokyo 105
August 23-27	The 8th Congress of International Ergonomics Association	Tokyo, Japan	Masamitsu Oshima, Director The Medical Information System Development Center Landick Akasaka Bldg. 2-3-4, Akasaka, Minato-ku Tokyo 107
September 5-10	International Conference on Magnetism-1982 (ICM-1982)	Kyoto, Japan	Prof. J. Kanamori Faculty of Science Osaka University Toyonaka, Osaka 560
September 6-10	International Conference on Nuclear Physics in the Cyclotron Energy Region	Osaka, Japan	Prof. M. Kondo Research Center for Nuclear Physics Osaka University Yamada-kami, Suita-shi Osaka 565
September (tentative)	6th International Sympo- sium on Contamination Control	Tokyo, Japan	Japan Air Cleaning Association 6-7-5, Soto-Kanda Chiyoda-ku, Tokyo 101

1982, continued

Date	Title	Site	For information, contact
October 4-6	3rd International Dental Congress on Modern Pain Control	Tokyo, Japan	Japan Convention Service, Inc. Nippon Press Center 8F. 2-2-1, Uchisaiwai-cho Chiyoda-ku, Tokyo 100
November 17-19	3rd JIM (Japan Institute of Metals) International Symposium	(undecided) Japan	The Japan Institute of Metals Aza Aoba, Aramaki Sendai-shi, Miyagi 980
undecided	International Conference on Mass Spectroscopy	Hawaii, U.S.A.	Prof. T. Tsuchiya Basic Science Lecture Room Chiba Institute of Technology 1-17-2, Tsudanuma Narashino, Chiba 275
undecided	International Rehabilitation Medicine Association Fourth World Congress	Sydney, Australia	Prof. G.G. Burniston Dept. of Rehabilitation Medicine Prince Henry Hospital Little Bay, N.S.W. 2036
undecided	Workshop on Marine Microbiology	Seoul, Korea	Korea Ocean Research and Development Institute PO Box 17, Yang-Jae, Seoul

1983

Date	Title	Site	For information, contact
May 10-12	Royal Australian College of Physicians ASM	Sydney, Australia	RACP, 145 Macquarie Street Sydney, NSW, 2000
May (tentative)	52nd ANZAAS Conference	Perth, Australia	Dr. G. Chandler University of Western Australia Nedlands, W.A. 6009
August 1-7	International Association for Dental Research	Sydney, Australia	Mr. Scott Gotjamanos Dept. of Pathology Perth Medical Centre Verdon Street Nedlands, W.A. 6009

1983, continued

Date	Title	Site	For information, contact
August 17-24	4th International Congress of Plant Pathology	Melbourne, Australia	Mr. B. Price Victorian Plant Research Institute Dept. of Agriculture Victoria, Swan Street Burnley, Vic. 3121
August 21-27	5th International Congress of Immunology	Kyoto, Japan	The Japanese Society for Immunology Institute of Virus Research Kyoto University Kawaracho, Shogoin Sakyo-ku, Kyoto 606
August 27-31	25th International Geographical Congress	Sydney, Australia	Australian Academy of Science PO Box 783 Canberra City, A.C.T. 2601
August 28-September 2	29th International Congress of Physiology	Sydney, Australia	Australian Academy of Science PO Box 783, Canberra City ACT 2601
August 28-September 3	The 3rd International Mycological Congress (IMC 3)	Tokyo, Japan	Prof. K. Tsubaki Institute of Biological Sciences The University of Tsukuba Sakura-mura, Ibaraki 305
August (tentative)	International Solar Energy Congress	Perth, Australia	Mr. P. Driver Honorary Secretary PO Box 123 Nedlands, W.A. 6009
October (tentative)	8th International Conference on Calcium Regulating Hormone	(Kobe), (tentative) Japan	Prof. T. Fujita 3rd Division Dept. of Medicine School of Medicine Kobe University 7-13, Kusunoki-cho Ikuta-ku, Kobe 650
October 29-November 3	71st FDI Annual World Dental Congress (Federation Dentaire Internationale)	Tokyo, Japan	Japan Dental Association (Japanese Association for Dental Science) 4-1-20, Kudan-kita Chiyoda-ku, Tokyo 102

1983, continued

Date	Title	Site	For information, contact
undecided	13th International Congress of Chemotherapy	Melbourne, Australia	Dr. B. Stratford St. Vincent's Hospital 59 Victoria Parade Fitzroy, Vic. 3065

1984

Date	Title	Site	For information, contact
Late August- Early Sept.	The 3rd International Congress on Cell Biology	Kyoto or Kobe, Japan	Japan Society for Cell Biology Shigei Medical Research Institute 2117 Yamada, Okayama 701-02

1985

Date	Title	Site	For information, contact
October 15-18	International Rubber Conference	Kyoto, (tentative) Japan	The Society of Rubber Industry, Japan Tobu Bldg., 1-5-26 Motoakasaka, Minato-ku Tokyo 107

## THE TENTH INTERNATIONAL SYMPOSIUM ON FAULT-TOLERANT COMPUTING

Rudolph J. Marcus

The Tenth International Symposium on Fault-Tolerant Computing was held 1-3 October, 1980, in Kyoto, Japan. Although no one from ONR/Tokyo was at this meeting, the digests of papers given at this meeting are available at this office and specific ones can be sent to those who request them.

The following topics were covered:

- Commercial systems
- Coding for mass storage
- Correction of memory faults
- Design verification
- Operating systems and synchronization
- Software fault avoidance and tolerance
- LSI testing
- Test generation
- Testing - probabilistic approaches
- Modeling for evaluation
- Coverage evaluation
- Evaluation as a design aid
- Self-checking
- System level diagnosis
- Multiple fault test generator
- Distributed system architectures
- Fault-tolerant logic design
- Dedicated design

The following papers were given at the symposium:

Name and Address	Title
- L. A. Boone Sperry Univac, Blue Bell PA 19422, U.S.A.	Availability, reliability and maintainability aspects of the Sperry Univac 1100/60
- Mughith Adham Amdahl Corporation	Deterministic reset for the Amdahl 470 V/6 computer
- Katsuichi Tomita Nippon Electric Co., Ltd Fuchu Factory 10, Nisshin-cho 1-chome Fuchu, Tokyo 183, Japan	A highly reliable computer system - its implementation and result
- Munehiro Goto Electronics Engineering Gifu University Kakamigahara Gifu, 504, Japan	Rates of unidirectional 2-column errors detectable by arithmetic codes

- Bella Rose  
Department of Computer  
Science  
Oregon State University  
Corvallis, OR 97331  
U.S.A.

Unidirectional error codes for  
shift register memories
- A. K. Bhatt  
Sperry Univac  
P.O. Box 43942  
St. Paul, MN 55164, U.S.A.

Random-double-track error  
correction in magnetic tapes
- W. C. Carter  
IBM Thomas J. Watson  
Research Center  
Yorktown Heights  
NY 10598, U.S.A.

Design and analysis of codes and  
their self-checking circuit  
implementations for correction  
and detection of multiple  
b-adjacent errors
- Shigeo Kanda  
Musashino Electrical  
Communication Laboratory  
Nippon Telegram and  
Telephone Corporation  
(N.T.T.)  
9-11, Midori-cho 3-chome  
Musashino-shi, Tokyo 180  
Japan

Single byte error correcting -  
double byte error detecting  
codes for memory systems
- Jega A. Arulpragasam  
Wang Laboratories, Inc.  
Lowell, MA 01851, U.S.A.

A design for process state  
preservation on storage unit  
failure
- A. V. Kuznetsov  
Institute for Problems of  
Information Transmission  
USSR Academy of Sciences  
Moscow, USSR

Masking triple fixed defects in  
memory
- Fumihiro Maruyama  
Information Processing  
Laboratory  
Fujitsu Laboratories Ltd.  
1015 Kamikodanaka  
Nakahara-ku, Kawasaki, 211  
Japan

Hardware verification and design  
error diagnosis
- Sheldon B. Akers  
General Electric Company  
Electronics Laboratory  
Syracuse, NY, 13221, U.S.A.

A procedure for functional  
design verification

- Andrej Lewinski  
Institute of Automatics  
Warsaw Technical University  
Warsaw, Poland

System for symbolic hardware  
algorithm verification
- Charles B. Weinstock  
SRI International  
Menlo Park, CA 94025, U.S.A.

SIFT: System design and  
implementation
- C. Gaudé  
CERCI, 56 rue Roger Salengro  
94120 Fontenay Sous Bois  
France

Design and appraisal of  
operating systems matched in  
selective active redundancy
- R. Valette  
Laboratoire d'Automatique  
et d'Analyse des Systems  
du Centre National de la  
Recherche Scientifique  
7, avenue du Colonel Roche  
31400 Toulouse, France

Monitors petri nets and error  
confinement
- Serge M. Miranda  
CERISS-INRIA, Université  
des Sciences Sociales  
Place A. France  
31041 Toulouse Cedex, France

DLP: A fault-tolerant  
decentralized locking protocol  
for distributed data
- Koji Okada  
Electrotechnical Laboratory  
1-1-4 Umezono, Sakura  
Niihari, Ibaraki, 305, Japan

Reliable program derivation in  
functional languages by  
applying Jackson's design  
method
- Flaviu Cristian  
Computing Laboratory  
University of Newcastle  
upon Tyne  
Newcastle upon Tyne NE1 7UR,  
U.K.

Exception handling and  
software-fault tolerance
- J. P. Banatre  
I.R.I.S.A. - I.N.R.I.A.  
Université de Rennes -  
Campus de Beaulieu  
35042 Rennes Cedex, France

A language framework for the  
reliable programming of  
distributed applications
- Anthony Y. Wei  
Department of Computer  
Science  
University of Illinois at  
Urbana-Champaign  
Urbana, IL 61801  
U.S.A.

Application of the  
fault-tolerant deadline  
mechanism to a satellite  
on-board computer system

- J. P. Black  
Department of Computer  
Science, and Computer  
Communications Networks  
Group  
University of Waterloo  
Waterloo, Ontario, Canada

An introduction to robust  
data structures
- John P. Hayes  
Department of Electrical  
Engineering  
University of Southern  
California  
Los Angeles, CA 90007  
U.S.A.

A calculus for testing complex  
digital systems
- C. Robach  
Lab IMAG BP 53X -  
38041 Grenoble Cedex  
France

Application oriented  
microprocessor test method
- M. El-Lithy  
Laboratoire d'Electronique  
d'Electrotechnique et  
d'Automatique de l'E.N.S.E.M.  
B.P. 850 - 54022 Nancy Cedex  
France

Bit-sliced microprocessors  
testing - a case study
- Se June Hong  
IBM Thomas J. Watson  
Research Center  
Yorktown Heights  
NY 10598, U.S.A.

Fitpla: A programmable logic  
array for function independent  
testing
- Hideo Fujiwara  
Department of Electronic  
Engineering  
Osaka University  
Yamada-kami, Suita-shi  
Osaka, 565, Japan

Universal test sets for  
programmable logic arrays
- Prabhakar Goel  
IBM Data Systems Division  
Poughkeepsie, NY 12602  
U.S.A.

An implicit enumeration algorithm  
to generate tests for  
combinational logic circuits
- Kozo Kinoshita  
Dept. of Information and  
Behavioral Sciences  
Faculty of Integrated Arts  
and Science  
Hiroshima University  
Higashi-senda-machi  
Hiroshima, 730, Japan

Test generation for  
combinational circuits by  
structure description

- Shigehiro Funatsu  
Nippon Electric Co., Ltd.  
Fuchu Factory  
10, Nisshin-cho 1-chome  
Fuchu, Tokyo 183, Japan

Digital fault simulation in  
bidirectional bus circuit  
environments
- Saied Bozorgui-Nesbat  
Center for Reliable  
Computing  
Computer Systems Laboratory  
Departments of Electrical  
Engineering and Computer  
Science  
Stanford University  
Stanford, CA 94305, U.S.A.

Structure design for testability  
to eliminate test pattern  
generation
- C. S. Venkatraman  
Department of Electrical  
Engineering  
University of Newcastle  
N.S.W. 2308, Australia

Transition count testing of  
sequential machines
- Hiroshi Eiki  
Department of Information  
Science  
Faculty of Engineering  
Kyoto University  
Yoshida-Honcho, Sakyo-ku  
Kyoto 606, Japan

Autonomous testing and its  
application to testable design  
of logic circuits
- S. Ohteru  
Department of Applied  
Physics  
Waseda University  
170, Nishi-Ohkubo 4-chome  
Shinjuku-ku, Tokyo 160  
Japan

Digital circuit test system  
using statistical method
- Rene David  
Laboratoire d'Automatique  
de Grenoble  
Institut National  
Polytechnique de Grenoble  
B.P. 46, 38402 St-Martin-  
d'Heres, France

Random testing of intermittent  
faults in digital circuits
- Xavier Castillo  
Carnegie-Mellon University  
Departments of Electrical  
Engineering and Computer  
Science

A performance-reliability model  
for computing systems

- Robert A. Rutledge  
International Business  
Machines Corporation  
Poughkeepsie, NY 12602  
U.S.A.

The reliability of memory  
subject to hard and soft  
failures
- J. Moreira de Souza  
Laboratoire d'Automatique  
et d'Analyse des Systemes  
de Centre National de la  
Recherche Scientifique  
7, avenue du Colonel Roche  
32400 Toulouse, France

A unified method for the  
benefit analysis of fault-  
tolerance
- Bjarne E. Helvik  
Electronics Research Laboratory  
The Norwegian Institute of  
Technology  
The University of Trondheim  
N-7034 Trondheim-NTH, Norway

Periodic maintenance, on the  
effect of imperfectness
- Steven E. Butner  
Center for Reliable Computing  
Computer Systems Laboratory  
Stanford University  
Stanford, CA 94305, U.S.A.

A statistical study of  
reliability and system load  
at SLAC
- N. L. Gunther  
Harvard Mathematics Dept.  
Cambridge  
MA, U.S.A.

Remarks on the probability of  
detecting faults
- J. J. Stiffler  
Raytheon Company  
Sudbury, MS, U.S.A.

Robust detection of intermittent  
faults
- Ravishankar Krishnan Iyer  
Center for Reliable Computing  
Computer Systems Laboratory  
Stanford University  
Stanford, CA 94305, U.S.A.

A study of the effect of  
uncertainty in failure rate  
estimation on system  
reliability
- B. Decouty  
IRISA-INRIA  
Campus de Beaulieu  
35042 Rennes Cedex, France

An evaluation tool of fault  
detection mechanisms
- A. Bellman  
Telettra S.p.A  
Switching Division  
20064 Gorgonzola (Milan)  
Italy

AFDTI redundancy plan

- T. S. Liu  
Honeywell Information  
Systems  
Phoenix, AZ, U.S.A.

Availability analysis of  
tree-structured computer  
communication systems
- M. Dal Cin  
Institute for Information  
Sciences  
University of Tubingen  
D-7400 Tubingen, West Germany

Self-testing and self-diagnosing  
multicomponent systems
- J. C. Laprie  
Laboratoire d'Automatique  
et d'Analyse des Systemes  
du Centre National de la  
Recherche Scientifique  
7, avenue du Colonel Roche  
32400 Toulouse, France

Dependability modeling of  
safety systems
- A. Grnarov  
Computer Science Department  
University of California  
Los Angeles, CA 90024, U.S.A.

On the performance of software  
fault-tolerance strategies
- Kwek Kuan Hong  
Department of Computer Science  
Tokyo Institute of Technology  
12-1, Ookayama 2-chome  
Meguro-ku, Tokyo 152, Japan

Signal reliability evaluation  
of self-checking networks
- Jacques Viaud  
Laboratoire d'Automatique  
de Grenoble  
Institute National Polytechnique  
de Grenoble  
B.P. 46, 3802 Saint-Martin-  
d'Heres, France

Sequentially self-checking  
circuits
- David Jun Lu  
Center for Reliable  
Computing  
Computer Systems Laboratory  
Departments of Electrical  
Engineering and Computer Science  
Stanford University  
Stanford, CA 94305, U.S.A.

Self-checking linear feedback  
shift registers
- Y. Crouzet  
Laboratoire d'Automatique  
et d'Analyse des Systemes  
du Centre National de la  
Recherche Scientifique  
7, avenue du Colonel Roche  
31400 Toulouse, France

Design specifications of a self-  
checking detection processor

- Takashi Nanya  
Central Research Laboratories  
Nippon Electric Co., Ltd.  
1-1, Miyazaki 4-chome  
Takatsu-ku, Kawasaki 213  
Japan

Design of self-checking  
asynchronous sequential  
circuits
- M. Courvoisier  
Laboratoire d'Automatique  
et d'Analyse des Systemes  
du Centre National de la  
Recherche Scientifique  
7, avenue du Colonel Roche  
31400 Toulouse, France

A self-testing arbiter circuit  
for multimicrocomputer systems
- Y. W. Yang  
Shaanxi Microelectronics  
Research Institute  
Lintong, Shaanxi  
People's Republic of China

Threshold  $I^2L$  totally self  
checking circuits
- J. G. Kuhl  
University of Iowa  
Iowa City, IA 52242  
U.S.A.

Some extensions to the theory of  
system level fault diagnosis
- K. J. Kunshier  
Sperry Univac  
P.O. Box 43942  
St. Paul, MN 55164, U.S.A.

Support processor based system  
fault recovery
- K. Matsui  
Department of Electrical  
Engineering  
National Defense Academy  
10-20 Hashirimizu 1-chome  
Yokosuka 239, Japan

A fault-diagnosis technique  
for closed flow networks
- V. K. Agarwal  
Department of Electrical  
Engineering  
McGill University  
3480 University Street  
Montreal, Canada, H3A 2A7

Predictions of multiple fault  
coverage capability
- Miron Abramovici  
Bell Telephone Laboratories  
Naperville, IL 60566, U.S.A.

Fault diagnosis in sequential  
circuits based on an effect-  
cause analysis
- A. Grnarov  
Computer Science Department  
University of California  
Los Angeles, CA 90024, U.S.A.

A highly reliable, distributed  
loop network architecture

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>- Tohru Kikuno<br/>Faculty of Engineering<br/>Hiroshima University<br/>8-2, Senda-cho 3-chome<br/>Hiroshima, 730, Japan</li> </ul>   | <p>Local controllers for packet<br/>switching networks</p>  |
| <ul style="list-style-type: none"> <li>- Clement K.-C. Leung<br/>Laboratory for Computer Science<br/>computer architecture(a)<br/>Massachusetts Institute of<br/>Technology<br/>Cambridge, MA 02139, U.S.A.</li> </ul>                                      | <p>Design of a fault-tolerant<br/>packet communication</p>  |
| <ul style="list-style-type: none"> <li>- Jacob A. Abraham<br/>Coordinated Science Laboratory<br/>University of Illinois at<br/>Urbana-Champaign<br/>Urbana, IL 61801, U.S.A.</li> </ul>   | <p>Easily testable, high speed<br/>realization of register-<br/>transfer-level operations</p>             |
| <ul style="list-style-type: none"> <li>- Dale G. Platteter<br/>Naval Weapons Support Center<br/>Crane, IN 47522<br/>U.S.A.</li> </ul>   | <p>Transparent protection of<br/>untestable LSI microprocessors</p>                                       |
| <ul style="list-style-type: none"> <li>- Koji Takeda<br/>Department of Computer Science<br/>Tokyo Institute of Technology<br/>12-1, Ohokayama 2-chome,<br/>Meguro-ku, Tokyo 152<br/>Japan</li> </ul>  | <p>Logic design of fault-tolerant<br/>arithmetic units based on the<br/>data complementation strategy</p> |
| <ul style="list-style-type: none"> <li>- L. Dellacorna<br/>Telettra S.p.A.<br/>Switching Division<br/>20064 Gorgonzola (Milan)<br/>Italy</li> </ul>   | <p>A micro-processor based control<br/>unit for high availability<br/>applications</p>                    |
| <ul style="list-style-type: none"> <li>- Peter L. Fu<br/>Center for Reliable Computing<br/>Computer Systems Laboratory<br/>Departments of Electrical<br/>Engineering and Computer Science<br/>Stanford University<br/>Stanford, CA 94305, U.S.A.</li> </ul> | <p>Consistency unit for fault-<br/>tolerant multiprocessors</p>   |
| <ul style="list-style-type: none"> <li>- Duenping Tsay<br/>Department of Computer and<br/>Information Science<br/>The Ohio State University<br/>Columbus, OH 43210, U.S.A.</li> </ul>   | <p>Design of a reconfigurable<br/>front-end processor for<br/>computer networks</p>                       |

- Kazuo Kawakubo  
Railway Technical Research  
Institute of Japan  
8-38, Hikari-cho 2-chome  
Kokubunji, Tokyo 185  
Japan

The architecture of a fail-safe  
and fault-tolerant computer  
for railway signalling device

- Hubert H. Huang  
GTE Products Corporation  
P. O. Box 205  
Mountain View  
CA 94042, U.S.A.

Fault-tolerant design of a  
modern receiving system

INTERNATIONAL CONFERENCE ON AUTOMATED MULTIPHASIC  
HEALTH TESTING AND SERVICES

Rudolph J. Marcus

An International Conference on Automated Multiphasic Health Testing and Services was held 4-6 October, 1980, in Tokyo. Although no one from ONR/Tokyo was at this meeting, the abstracts of papers given at this meeting are available at this office and specific ones can be sent to those who request them.

A listing of speakers at this meeting, their addresses, and titles of their papers follows:

Name and Address	Title
- Sergio Cerutti Istituto di Elettrotecnica ed Elettronica-Politecnico di Milano Piazza Leonardo da Vinci 32 - 20133 Milano Italy	Semantic models for automated medical care testing and diagnosis checking
- Rafael S. Carel MOR Institute and the Department of Preventive and Social Medicine Tel Aviv University P. O. Box 938 Bne-Brak Israel	Computerized multiphasic screening for identification of high risk groups
- Ingrid Reynolds Senior Research Psychologist Health Commission of New South Wales Medicheck Rafael Center P. O. Box A128 Sydney South, 2000 Australia	The prevalence of psychosocial problems: a study of 37,678 Sydney adults
- H. R. Oldfield Jr. Chairman of the Board Medequip Inc. 979 Rollins Avenue Rockville, MD 20852 U.S.A.	A new AMHT based medical information system for health care in industry
- Sumiko Takahashi Midori Health care Foundation 22 Tarumicho 3-chome Suita, Osaka 564 Japan	A follow-up study of those who needed further examination in multiphasic health check-ups

- Daikichi Kobata  
Health Administration Center  
Otemae Hospital  
Otemaeno-cho, Higashi-ku  
Osaka City, Japan

Follow-up study in AMHTS  
belonged to a general Hospital
- Shigeo Hinohara  
AMHTS center in  
Tokai University Hospital  
Department of Clinical  
Pathology  
School of Medicine  
Tokai University  
Bohseidai, Isehara 259-11  
Japan

Cancers of examinees and it's  
follow-up system in AMHTS
- Keijiro Kiyoshima  
Perfect Liberty Health  
Control Center  
4-55, Karamono-cho  
Higashi-ku, Osaka, Japan

Did repetition of biannual AMHT  
succeed in eliminating  
cancer deaths?
- Hiromichi Yoshikawa  
Sumitomo Mutual Life  
Insurance AMHTS  
2-2-5, Nakanoshima  
Kita-ku, Osaka 530, Japan

Analysis of the effect of food  
tastes on risk factors of adult  
diseases and biological age in  
AMHTS examinees
- Yoshimi Terada  
Midori Health Care  
Foundation  
22 Tarumicho 3-chome  
Suita, Osaka 564, Japan

A study on dietary habits and  
knowledge about nutrition of the  
examinees in an AMHTS
- Bun-ichi Fujimori  
Nagano General Health  
Promotion Center  
Naganoken Sohgo-h-kenkoh Center  
Wakasato, Nagano City 381-01  
Japan

Statistical and comparative  
studies on obesity
- Nobuhiko Kasezawa  
Shizuoka Medical Center  
3-1-1, Toro, Shizuoka-shi  
Shizuoka 422MZ, Japan

Practical evaluation of  
weight/height ratio as  
obesity index in AMHTS
- Hiromichi Yoshikawa  
Sumitomo Mutual Life  
Insurance AMHTS  
2-2-5, Nakanoshima, Kita-ku  
Osaka 530, Japan

Analysis of physical strength  
tests of AMHTS examinees

- K. Shimizu  
Tohma Hospital Sogo Kenshin  
system  
2-137, Suehiro, Kumagaya-shi  
Saitama 360, Japan

Cytoscreening for uterine cancer  
at AMHTS
- Kiyonobu Sakagami  
Matsushita Health  
Administration Center  
570, 2-16, Kaneshita-cho  
Moriguchi, Osaka, Japan

Medical census on anemia
- Shigeru Kohsokabe  
Tojitsu Medical Center of  
AMHTS  
Dept. of Internal Medicine  
Tokyo Medical College Hospital  
6-7-1 Nishishinjuku  
Shinjuku-ku, Tokyo, Japan

A study of rheumatoid factor  
in the automatic multiple  
health service (AMHTS)
- S. J. Wojcik  
Belgium IBM  
185 bd Thirov  
6000 Charleroi, Belgium

Discriminant analysis of  
multipuncture skin testing  
in breast cancer
- Krikor Soghikian  
Kaiser-Permanente Medical  
Center  
280 West MacArthur  
Boulevard  
Oakland, CA 94611, U.S.A.

Outcomes and costs of selected  
preventive health maintenance  
programs
- Morris F. Collen  
Director, Technology  
Assessment  
Kaiser-Permanente  
Medical Care Program  
3700 Broadway  
Oakland, CA 94611, U.S.A.

Evaluation of AMHTS
- Mihoko Okada  
Department of General  
Education  
Niigata University  
2 nocho, Ikarashi,  
Niigata City 250-21, Japan

An interactive system for  
programming free data  
management and analysis
- Toshihiro Fukuda  
College of Paramedical  
Technology  
Yamaguchi University  
1144 Ogushi Ube, 755, Japan

Studies on mass screening for  
liver diseases

- Toshiro Tango  
Medical Informatics Group  
The Tokyo Metropolitan  
Institute of Medical  
Science  
3-18-22, Hon-komagome  
Bunkyo-ku, Tokyo 113, Japan

On the "individual difference  
quotient" of clinical  
laboratory data
- Seiichi Takasugi  
Institute of Medical  
Electronics  
University of Tokyo  
7-3-1 Hongo, Tokyo 113  
Japan

Information content of time  
dependent data for normal  
ranges of individuals
- Haruki Ueno  
Department of Systems  
Engineering  
Tokyo Denki University  
Hatoyama, Saitama 350-03  
Japan

Feasibility of AMHT data  
interpretations by means of  
artificial intelligence
- S. Sitharma Iyengar  
The Department of  
Computer Science  
Louisiana State University  
Baton Rouge, LA 70803  
U.S.A.

Establishment of a distributive-  
based computer network for  
hospitals
- Toshio Yasaka  
P. L. Medical Data Center  
1, Kamiyama-cho  
Tondabayashi-shi  
Osaka 584, Japan

Findings in aging; and survey on  
regional differences
- Ryosei Kashida  
Director  
Kanto Central Hospital  
6-25-1 Kamiyoga  
Setagaya-ku, Tokyo 158  
Japan

Introduction: concept of subject  
specific normal range
- G. Z. Williams  
Institute of Health Research  
Institutes of Medical  
Sciences  
2200 Webster Street  
San Francisco, CA 94115  
U.S.A.

Individual-specific normal ranges  
and identification of trend  
changes in serum constituents

- Eugene K. Harris  
Chief, Laboratory of  
Applied Studies  
Division of Computer  
Research & Technology  
National Institutes of Health  
Bldg. 12A, Room 2041  
Bethesda, MD 20205, U.S.A.

Use of statistical models to  
detect subject-specific changes
- Toshio Yasaka  
P. L. Medical Data Center  
1, Kamiyama-cho  
Tondabayashi-shi  
Osaka 584, Japan

Subject-specific normal ranges:  
ideal, implementation, by-  
products and future  
development
- Hiroshi Takeda  
The First Department of Medicine  
Osaka University Hospital  
1-1-50, Fukushima  
Fukushima-ku, Osaka 553, Japan

Analysis of AMHTS examinee  
data for multivariate  
individual normal range
- Takako Igarashi  
Toyosu - Kosei Hospital  
Toyosu - 4-1-18  
Koto-ku, Tokyo, Japan

On successful two-year  
computerization of our hospital
- Hiromichi Yoshikawa  
Sumitomo Mutual Life  
Insurance AMHTS  
2-2-5, Nakanoshima  
Kita-ku, Osaka 530, Japan

A study of medical evaluation of  
multivariate normal range and  
biological age
- T. Nakamura  
Scientific Data Center of  
Atomic Bomb Disasters  
Nagasaki University  
School of Medicine  
12-4 Sakamoto-machi  
Nagasaki 852, Japan

Retrospective study on predicting  
factors for disease-specific  
death using historical records
- Jyunichi Sugiyama  
Life Planning Center  
Sasakawa Memorial Hall  
3-12-12, Minato-ku  
Tokyo 108, Japan

Local data base for continuous  
management of some chronic  
adult diseases
- Takakazu Imai  
Yokohama Multiphasic  
Health Checkup Center  
43-48, 2-chome  
Nakatehara, Kohoku-ku  
Yokohama, Japan

Studies on cholecystography

- K. Suzuki  
Shizuoka Medical Center  
3-1-1 Toro, Shizuoka-shi  
Shizuoka-ken, Japan

The usefulness of low-gamma  
type X-ray film in  
gastrointestinal diagnosis  
in AMHTS
- S. Kobayashi  
Tohma Hospital  
Sogo Kenshin System  
2-137, Suehiro  
Kumagaya-shi, Saitama 360  
Japan

Gallblader screening by echogram  
at AMHTS
- Hideko Watanabe  
Midori Health Care  
Foundation  
22 Tarumicho 3-chome  
Suita, Osaka 564, Japan

Analytical studies on early  
detection of the cervix cancer  
using the self-collecting smear
- Masao Miyamae  
Tokyo Metropolitan  
Komagome Hospital  
Takamatsu 6-18-4, Nerima-ku  
Tokyo, Japan (home address)

Picture frustration study  
calculation and recording system
- Hiroshi Kiyose  
Mitsui Memorial Hospital  
1, Kanda Izumi-cho  
Chiyoda-ku, Tokyo 101  
Japan

Study on control survey results  
in JAHT
- H. Tohma  
Tohma Hospital  
Sogo Kenshin System  
2-137, Suehiro, Kumagaya-shi  
Saitama 360, Japan

Screening for breast cancer  
at AMHTS
- Yasuaki Takehara  
Kanto Central Hospital  
6-25-2, Kamiyoga  
Setagaya-ku, Tokyo 158  
Japan

Clinical application of newly  
developed ultrasonic mass-  
screening system for the breast
- Toshiji Kobayashi  
Department of Clinical  
Laboratory  
School of Medicine  
University of Occupational  
and Environmental Health  
1-1, Iseigaoka, Yahata  
Nishi-ku, Kitakyushu City 807  
Japan

Clinical usefulness in contact  
scanning for the diagnosis of  
breast cancer

- Mitsuko Noro  
Tojitsu Medical Center of  
AMHTS  
Department of Internal  
Medicine, Tokyo Medical  
College Hospital  
3-chome 10-4  
Higashi Nihonbashi  
Chuo-ku, Tokyo, Japan

The 1st report: relationship of  
cigarette smoking to some  
laboratory examination's data
- F. Bobbie Collen  
Kaiser-Permanente Medical  
Care Program  
3700 Broadway  
Oakland, CA 94611  
U.S.A.

Health education at Kaiser-  
Permanente, Oakland, California
- Toru Iwatsuka  
Aichi Prefectural Center  
of Health Care  
3-2-1 San-no-maru  
Naka-ku, Nagoya 460, Japan

Weight control and exercise  
schools in AMHTS
- Toshikazu Wakatsuki  
Saku Central Hospital  
197 Usuda-machi  
Minami-saku-gun  
Nagano Prefecture, 384-03  
Japan

Mass health screening and health  
education in Japan rural  
communities
- Keijiro Kiyoshima  
Perfect Liberty Health  
Control Center, Osaka  
4-55, Karamono-cho  
Higashi-ku, Osaka, Japan

MHTS and health education at a  
private health control center
- Shigeaki Hinohara  
c/o Sasakawa Memorial Hall  
12-12  
Mita 3-chome, Minato-ku  
Tokyo, Japan

What the life planning center  
signifies
- Motoko Imamura  
Toshiba Multiphasic  
Health Screening Center  
6-3-22 Higashi-Oi  
Shinagawa-ku, Tokyo 140, Japan

Scrutiny into insufficient  
mydriasis in "non-mydriatic"  
retinography (2)
- K. Ito  
Tojitsu Sogo Kenshin Center  
Tojitsu Kenpo Kaikan 3F  
3-10-4, Higashi-Nihonbashi  
Chuo-ku, Tokyo 103, Japan

Studies of blood pressure in  
extremities

- Nobutaka Doba  
The Life Planning Center  
3-12-12, Mita, Minato-ku  
Tokyo 108, Japan  
  
Preliminary report on detection  
and management of essential  
hypertension
- Makoto Sato  
Mikawa Aichi Prefectural  
Center of Health Care  
1-3, Aza, Jyuan, Hashira-cho  
Toyohashi-shi, Aichi-ken 440  
Japan  
  
Clinical experience of an  
automated PCG analysis
- Takeshi Watanabe  
Aichi Prefectural Center  
of Health Care  
3-2-1, San-no-maru, Naka-ku  
Nagoya 460, Japan  
  
Clinical evaluation on the four  
different ECG analyzers  
recently developed in Japan
- T. Itagaki  
Yokufukai Hospital  
Tohma Hospital Sogo Kenshin  
System  
2-137, Suehiro, Kumagaya-shi  
Saitama 360, Japan  
  
Cardiovascular risk factors in  
obesity and glucose intolerance
- Hitoshi Yamada  
Gifu Health Care Center  
(Gifukeritsutsu Kenko  
Kanriin)  
4-6-2, Noishiki Gifu-shi  
Gifu-shi 500, Japan  
  
Statistical studies on biochemical  
data in view to sex, age and  
blood type in AMHTS. -GTP  
data
- Nobuo Nishiyama  
Gifu Health Care Center  
(Gifukeritsutsu Kenko Kanriin)  
4-6-2, Noishiki  
Gifu-shi 500, Japan  
  
Statistical studies on biochemical  
data in view to sex, age and  
blood type in AMHTS.  
HDL-Cholesterol data
- Nobuhiko Karezawa  
Shizuoka Medical Center  
3-1-1, Tori, Shizuoka-shi  
Shizuoka 422 Mz  
Japan  
  
The local variations of serum  
lipid levels in Shizuoka  
prefecture
- Shigeaki Hinohara  
The Life Planning Center  
c/o Sabo kaikan 7-5,  
Hirakawa-cho 2-chome  
Chiyoda-ku, Tokyo 102  
Japan  
  
Comparison of the results of  
routine adult health screening  
and multiphasic blood tests  
done for the inhabitants of a  
rural village and its problems

- S. Miyakawa  
Toshiba Multiphasic Health  
Screening Center  
6-3-22, Higashi-Ooi  
Shinagawa-ku, Tokyo, Japan

Elevation of the elevated  
hematocrit level as a risk  
factor for ischemic heart and  
cerebral disease

- T. Mihara  
Meiji Life Automated  
Multiphasic Health Testing  
Center  
c/o Odakyu Meiji-seimei  
bld. No.8-3  
Nishi-Shinjuku 1-chome  
Shinjuku-ku, Tokyo 160  
Japan

Measurement of Hemoglobin  
A<sub>1</sub> and glucose tolerance test  
in AMHTS

- Mitsuo Hamahata  
Sumitomo Mutual Life  
Insurance AMHTS  
2-2-5, Nakanoshima 1 Kita-ku,  
Osaka 530, Japan

Long-term evaluation of  
multivariate precision control  
chart for multichannel analyzer

## SEVENTH INTERNATIONAL CODATA CONFERENCE

Rudolph J. Marcus

The Seventh International CODATA Conference was held 8-11 October, 1980, in Kyoto, Japan. Although no one from ONR/Tokyo was at this meeting, the abstracts of papers given at this meeting are available at this office and specific ones can be sent to those who request them.

A listing of speakers at this meeting, their addresses, and titles of their papers follows:

Name and Address	Title
- Philip H. Abelson Editor, <i>Science</i> 1515 Massachusetts Avenue N.W., Washington, D.C. 20005, U.S.A.	Use of data in basic and applied science
- T. Rikitake Tokyo Institute of Technology 12-1, Ohokayama 2-chome Meguro-ku, Tokyo 152 Japan	Earthquake prediction
- D. Shimozuru Earthquake Research Institute University of Tokyo 16-11 Yayoi 2-chome Bunkyo-ku, Tokyo 113 Japan	Prediction of volcanic eruptions - methods and case study
- Motoo Kimura National Institute of Genetics 1, 111, Yata, Mishima Shizuoka	Data on our evolutionary heritage
- Egil Jellum Institute of Clinical Biochemistry Rikshospitalet Oslo 1, Norway	Computerized gas chromatography - Mass spectrometry in biomedical studies. Coordination and handling of the data
- S. Peter Spragg Department of Chemistry University of Birmingham Birmingham B15 2TT United Kingdom	Data collection from 2-dimensional gel-electrophoresis experiments

- T. M. Jovin  
Max-Planck-Institute für  
Biophysikalische Chemie  
D-3400 Goettingen  
Federal Republic of  
Germany

Computer in flow analysis and  
sorting
- A. E. Bussard  
Cellular Immunology  
Institut Pasteur  
75015 Paris, France

The generation of diversity of  
antibodies. A problem of  
combinatorial analysis
- Kensuke Sato  
Research Foundation on  
Traffic Medicine  
1-9-3 Higashi Ikebukuro  
Toshima-ku, Tokyo 170  
Japan

Higher order activities of  
biological systems
- Sherman P. Fivozinsky  
Office of Standard  
Reference Data  
National Bureau of  
Standards  
Washington D.C. 20234  
U.S.A.

Compilation and evaluation of  
radiation depth-dose data from  
electron accelerators used for  
radiotherapy: Experiences of a  
pilot data project in a  
hospital environment
- Isamu Matsumoto  
Research Institute of  
Medical Mass Spectrometry  
Kurume University School  
of Medicine  
67, Asahi-cho  
Kurume, Fukuoka 830  
Japan

A new computer program for  
chemical diagnosis of metabolic  
diseases
- Masao Nakamura  
Department of Information  
Science  
Faculty of Engineering  
Fukui University  
45-1, Ninomiya 4-chome  
Fukui

Evaluation of neuronal spike  
train data by new  
methodologies of waveform  
discrimination and point  
process analysis
- G. Ignazi  
Laboratoire d'Anthropologie  
et d'Ecologie Humaine  
45 rue des Saints-Peres  
75006 Paris, France

ERGODATA, an international data  
bank in biometry and ergonomics:  
Conversational and developments

- Israel Paz  
Technion Israel Institute  
of Technology  
Haifa, Israel

The automation of human fertility  
analysis
- Yoshikatsu Miyashita  
Toyohashi University of  
Technology  
Tempaku, Toyohashi 440  
Japan

The use of cluster analysis and  
display method of pattern  
*recognition in structure-*  
activity studies of antibiotics
- Hideaki Sugawara  
Institute of Physical and  
Chemical Research  
28-8, Honko Magome 2-chome  
Bunkyo-ku, Tokyo 113  
Japan

Development of a national  
information system of  
laboratory of organisms
- Shigeru Suzuki  
National Institute of  
Agricultural Sciences  
Fujimoto, Yatabe-cho  
Tsukuba-gun, Ibaraki 305  
Japan

On the use of a data base system  
for information processing in  
plant breeding
- V. V. Sytchev  
Moscow Power Engineering  
Institute  
Moscow 105835  
U.S.S.R.

Joint proceedings of thermal,  
calorical, and acoustical  
experimental data for  
compilation of thermodynamic  
tables
- Lev V. Gurvich  
Institute for High  
Temperatures  
Moscow, U.S.S.R. 127412

Data bank for thermodynamic  
properties of pure substances
- Boris Vodar  
LIMHP-CNRS, Villetaneuse  
and AIRAPT-BOURGOGNE  
B. P. 90, 71203 Le Greusot  
France

Planning of a multidisciplinary  
data bank on high pressures  
(Piezodata)
- Jingo Chao  
Thermodynamic Research  
Center  
Texas A&M University  
College Station  
TX 77843, U.S.A.

Molecular structure and perfect  
gas thermodynamic properties of  
simple chemical substances
- Henry V. Kehiaian  
CNRS, Marseille  
France

The fluid phase equilibrium data  
project of the IUPAC  
subcommittee on  
thermodynamic tables

- K. Watanabe  
Department of Mechanical Engineering  
Keio University  
832, Hiyoshi-cho  
Kohoku-ku, Yokohama 223  
Japan

Necessity for establishing the skeleton tables on the thermodynamic properties of fluids
- A. P. Kudchadker  
Dept. of Chemical Engineering, Indian Institute of Technology  
Powai, Bombay 400 076, India

Chemical thermodynamic properties of coal chemicals: aromatic hydrocarbons,
- T. Ozawa  
Electrotechnical Laboratory  
Higashi, Yatabe-cho  
Tsukuba-gun, Ibaraki 305  
Japan

Screening of latent heat-thermal energy storage materials by using evaluated thermodynamic data
- A. R. J. Cole  
School of Chemistry  
University of Western Australia  
Nedlands 6009  
Western Australia

Wavenumber standards in the infrared
- Shinnosuke Saeki  
National Chemical Laboratory for Industry  
Higashi, Yatabe-cho  
Tsukuba-gun, Ibaraki 305  
Japan

Preliminary research for the establishment of spectral data bank in National Chemical Laboratory for Industry
- Juri P. Drobyshev  
Data Centre  
Novosibirsk 630090, U.S.S.R.

Centre of data for research in Siberian Branch of U.S.S.R. Academy of Sciences
- Vladimir Stepanek  
Institute of Inorganic Chemistry and Environmental Research Center  
Prague, Czechoslovakia

The evaluation of the results of spectrochemical analyses in terms of information quantities
- Kozo Kuchitsu  
Department of Chemistry  
Faculty of Science  
University of Tokyo  
3-1 Hongo 7-chome  
Bunkyo-ku, Tokyo 113  
Japan

Critical evaluation and compilation of molecular geometry data determined by gas electron diffraction

- G. Gergerhoff  
University of Bonn  
Bonn, West Germany

Inorganic crystal structure data  
base
- Gen Sato  
Mineralogical Institute  
Faculty of Science  
University of Tokyo  
3-1 Hongo 7-chome  
Bunkyo-ku, Tokyo 113  
Japan

Mineral and inorganic crystal  
data base
- Richard Sinding-Larsen  
Norwegian Institute of  
Technology  
Geir Strand  
Geological Survey of Norway

Quantitative integration of  
mineral exploration data from  
the Grong Mining District,  
Norway
- Frank W. Allen  
Management Information  
Systems Department  
University of Arizona  
Tucson, AZ 85721  
U.S.A.

The electric power research  
institute water supply data  
base: A scarce resource  
research tool
- Shigeo Aramaki  
Earthquake Research  
Institute  
University of Tokyo  
3-1 Hongo 7-chome  
Bunkyo-ku, Tokyo 113  
Japan

Data base for the igneous rocks  
of Japan
- Dan Gill  
Geological Survey of  
Israel  
Jerusalem, Israel

A real value assessment of the  
natural resources endowment of  
Israel
- Viktor E. Hampel  
Lawrence Livermore  
Laboratory, Integrated  
Information Systems  
Mail Stop L-275  
Box 808, Livermore  
CA 94550, U.S.A.

Database management systems for  
numeric/structured data:  
An overview
- Michael Lucas  
Universite de Nantes  
Mathematiques et  
Informatique,  
2, Chemin de la  
Houssiniere,  
F - 44072 Nantes Cedex, France

Interactive graphical techniques  
for data comprehension

- Claude Michel  
Sintra EF  
26 rue Malakoff,  
92600 Asnieres, France

Tool system for computer aided design of highly performing digital systems
- N. Tubbs  
OECD, Paris, France

Application of a DBMS at NEA data bank: Problems and experience with a large data base on a small computer
- Stephen E. Jones  
Lawrence Livermore  
National Laboratory  
Livermore, CA 94550  
U.S.A.

Using a relational DBMS in the scientific community
- Nobuyuki Tanaka  
Department of Chemistry  
Faculty of Science  
Tohoku University  
Aoba, Aramaki, Sendai  
Miyagi 980, Japan

User-oriented database management system, COOD and its applications to on-line data storage and retrieval
- Bettijoyce Breen Molino  
National Bureau of  
Standards  
Washington, D.C. 20234  
U.S.A.

Omnidata and related software as developed and applied by The Office of Standard Reference Data for on-line retrieval analysis, and manipulation of NSRDS data bases
- Kivoto Mitsui  
National Research  
Laboratory of Meteorology  
Tateno, Yatabe-cho  
Tsukuba-gun, Ibaraki 305  
Japan

Improving reproducibility of low temperature standards
- Eliahu Hoffman  
National Center of  
Scientific and  
Technological  
Information (COSTI)  
P.O. Box 20125  
84, Hachashmonaim Street  
Tel-Aviv, Israel

Vapor pressure data of simple organic substances, their availability and reliability
- Andrzej Maczynski  
Institute of Physical  
Chemistry of the Polish  
Academy of Sciences and  
Institute of Industrial Chemistry  
Warsaw, Poland

Vapor pressure compilations - critical review and new proposals

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>- R. Audinos<br/>University Paul Sabatier<br/>Toulouse, France</li> </ul>  | <p>Data in electromembrane processes</p>  |
| <ul style="list-style-type: none"> <li>- P. Zuman<br/>Clarkson College of<br/>Technology<br/>Potsdam, NY 13676<br/>U.S.A.</li> </ul>  | <p>Evaluation and compilation of electrochemical data for organic and inorganic compounds</p>                   |
| <ul style="list-style-type: none"> <li>- Mitso Sato<br/>Department of Chemistry<br/>Gunma University<br/>5-1 Tenjin-cho 1-chome<br/>Kiryu, Gumma 376,<br/>Japan</li> </ul>  | <p>Quantification of patterns and its application to the analysis of variance</p>                               |
| <ul style="list-style-type: none"> <li>- Clemens Jochum<br/>Department of Chemistry<br/>University of Washington<br/>Seattle, WA 98195<br/>U.S.A.</li> </ul>  | <p>Linear and nonlinear data bases with underlying variable factor analysis</p>                                 |
| <ul style="list-style-type: none"> <li>- Vladimir Stepanek<br/>Environmental Research<br/>Center and Institute of<br/>Inorganic Chemistry<br/>Prague, Czechoslovakia</li> </ul>                                   | <p>Information content of analytical signals and its evaluation</p>   |
| <ul style="list-style-type: none"> <li>- Nobuo Ohbo<br/>Department of Information<br/>Science, Faculty of<br/>Science<br/>University of Tokyo<br/>3-1 Hongo 7-chome<br/>Bunkyo-ku, Tokyo 113<br/>Japan</li> </ul> | <p>Graph-based region analyzer</p>  |
| <ul style="list-style-type: none"> <li>- Ruediger R. Hartwig<br/>IMB Scientific Center<br/>Tiergartenstrasse 15,<br/>D-6900 Heidelberg<br/>Germany</li> </ul>   | <p>Hyperbolic subsegmental interactive analysis of curve-, surface- and space-type data</p>                     |
| <ul style="list-style-type: none"> <li>- Niichi Nishiwaki<br/>Department of Geology<br/>and Mineralogy<br/>Kyoto University<br/>Yoshida-Honcho, Sakyo-ku<br/>Kyoto 606, Japan</li> </ul>                          | <p>The BIWA system as a prototype data base to manage various kinds of data in geology and related sciences</p> |

- Kiyoshi Wadatsumi  
Department of  
Geosciences  
Osaka City University  
459, Sugimoto-cho,  
Sumiyoshi-ku  
Osaka 558, Japan

Interactive graphic data entry  
and display for the  
geo-database system
- Marie-Jose Roulet  
Laboratoire de  
Geodynamique  
75230 Paris Cedex 05, France

Drilling's data. Contribution  
to a geological data bank
- Tositomo Kanakubo  
Geographical Survey  
Institute  
Ministry of Construction  
of Japan  
Higashi, Yatabe-cho  
Tsukuba-gun, Ibaraki 305  
Japan

The use of "digital national  
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- Donald D. Wagman  
National Bureau of  
Standards  
University of Sussex  
Brighton, N1, United Kingdom

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- Felix Chayes  
Geophysical Laboratory  
Carnegie Institution of  
Washington  
Washington D.C., U.S.A.

Attitudes toward data in the  
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- Micah I. Krichevsky  
National Institutes of  
Health  
Bethesda, MD 20205, U.S.A.

Cluster analysis of  
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- K. Osaki  
Faculty of Pharmaceutical  
Sciences  
Kyoto University  
Oiwake-cho, Kitashirakawa  
Sakyo-ku, Kyoto 606  
Japan

An intermolecular contact check  
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- R. W. A. Oliver  
Department of  
Biochemistry  
University of Salford  
Salford M5 4WT, Lancashire  
United Kingdom

The evaluation of drug mass  
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- Tomasz Plebanski  
Polish Committee of  
Standardization and  
Measures  
ul. Elektoralna 2,  
00-139 Warsaw, Poland

Discussion concerning possible  
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- Dobrin D. Burev  
Base for Automation of  
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Bulgarian Academy of  
Science  
Lenin Boulevard 72  
Sofia, Bulgaria

Adaptive method for dual  
parametric identification and  
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linear stochastic dynamic  
plants
- Hideto Sato  
University of Tsukuba  
Tennodai, Sakura-mura  
Niihari-gun, Ibaraki 305  
Japan

Derivability and comparability  
among non-atomic data
- John B. Rose  
Division of the General  
Information Programme  
UNESCO, Place Fontenoy  
France

Data needs for development
- F. D. Gault  
University of Durham  
Durham City, DH1 3LE  
United Kingdom

The impact of a data base on  
elementary particle physics  
research in the U. K.
- Y. Itikawa  
Institute of Plasma Physics  
Nagoya University  
Furocho, Chikusa-ku  
Nagoya 464, Japan

Database and retrieval-display  
system of atomic data for  
thermonuclear fusion research
- Masatomo Togasi  
Department of Physics  
Faculty of Science  
Hokkaido University  
Nishi 6-chome, Kita 12-jo  
Kita-ku, Sapporo 060  
Japan

Compilation of nuclear reaction  
data in Japan
- Betty F. Maskewitz  
Engineering Physics  
Information Centers (EPIC)  
Oak Ridge National  
Laboratory  
Oak Ridge, TN 37830  
U.S.A.

Data base for rapid response  
to power reactor problems

- Shunichi Iwata  
Faculty of Engineering  
University of Tokyo  
3-1 Hongo 7-chome  
Bunkyo-ku, Tokyo  
Japan

Materials data base for energy applications
- Paolo Tiberio  
CIOCCNR  
Istituto di Elettronica  
Universita di Bologna  
40136 Bologna, Italy

A geographic data base for computer-assisted cartography
- Lefebvre Dominique  
Laboratoire de Geodynamique  
Universite P. et M. Curie  
Paris 5e, France

Correspondencies analysis in thematic cartography
- Claire David  
Laboratoire de Geodynamique  
Universite P. et M. Curie  
4, Place Jussieu  
75230 Paris Cedex 05  
France

Pattern recognition and cartographic themes combination for water resources mapping
- Yasuo Shimizu  
Department of Earth Science  
Nagoya University  
Furo cho, Chikusa-ku  
Nagoya 464, Japan

SMLESIS - Database for multidisciplinary researches with applications to environmentology
- P. M. Appoo  
BNF Metals Technical Centre  
Wantage, United Kingdom

A computerized materials data base for an automotive manufacturer
- Eva Raimann Cabral  
CEPEL-Electrical Energy Research Center  
P. O. Box 2754-20000  
Rio de Janeiro, Brazil

Data on corrosion protection in electrical power equipment
- Y. Masahiko  
Ex-Director General  
National Chemical Laboratory for Industry  
Higashi Yatabe-cho  
Tsukuba-gun, Ibaraki 305

Review on physico-chemical properties data activities in government sponsored organizations and industrial fields in Japan
- I. Mistrik  
CID-SfS  
Heidelberg, West Germany

Integrated information and communication system for a scientist: Analysis and design

- Takeo Yamamoto  
Computer Center  
University of Tokyo  
1-1 Yayoi 2-chome  
Bunkyo-ku, Tokyo 113  
Japan

Five years of chemical Information  
service with tool-IR
- Wayne D. Dominick  
Computer Science Department  
University of Southwestern  
Louisiana, Lafayette  
LA 70505, U.S.A.

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and Part II. Analysis
- Hisako Uchida  
The Japan Information  
Center of Science and  
Technology  
5-2, Nagata-cho 2-chome  
Chiyoda-ku, Tokyo 100

The JICST on-line mass spectral  
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- Sadaaki Miyamoto  
Scientific Information  
Processing Center  
University of Tsukuba  
Tennodai, Sakura-mura  
Niihari-gun, Ibaraki 305  
Japan

Synthesis of scientific information  
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- J. M. Monget  
Ecole Nationale Supérieure  
des Mines de Paris  
Sophia-Antipolis  
Valbonne 06560, France

Current and potential applications  
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- Michele Caputo  
Istituto di Fisica  
G. Marconi  
Universita, Rome, Italy

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- Nenad Preloq  
Referral Centre of the  
University of Zagreb  
Trg Marsala Tita 3  
41000 Zagreb, Yugoslavia

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- Ivan Wiesenberger  
Charles University of  
Prague  
120 00 Prague 2  
Czechoslovakia

Systems of remote sensed data

- Ryozauro Yamamoto  
Geophysical Faculty  
Science Department  
Kyoto University  
Kitashirakawa-Oiwakecho  
Sakyo-ku, Kyoto 606, Japan

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- M. Schoenberg  
Hoechst A.G., Frankfurt  
Federal Republic of Germany

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- Keith W. Reynard  
Engineering Sciences Data  
Unit Ltd, London  
United Kingdom

ESDU - Fulfilling industrial needs  
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- J. H. Westbrook  
General Electric Company  
R&D Center, Schenectady  
NY 12305, U.S.A.

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- Andrej Bylicki  
Institute of Physical  
Chemistry  
Polish Academy of Science  
01-224 Warsaw, Poland

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- H. Behrens  
Fachinformationszentrum  
Energie Physik  
Mathematik GmbH, Karlsruhe  
Federal Republic of Germany

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What has been done, what should  
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- Anna Beck  
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New Brunswick, NJ 08903  
U.S.A.

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- Hajime Tanaka  
Faculty of Science  
Hokkaido University  
Nishi 7-chome, Kita 11-jo  
Kita-ku, Sapporo 060  
Japan

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- Francois Bouille  
Equipe HBDS  
Institut de Programmation  
Universite Pierre et  
Marie Curie  
Paris, France

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sources, at different scales

- Robert E. Nolan  
Evaluation Research  
Cooperation  
Vienna, VA 22180, U.S.A.

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- John Rumble  
OSRD, National Bureau of  
Standards  
Washington D.C. 20234  
U.S.A.

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- Elaine T. Lisboa  
Computer Science Department  
University of Southwestern  
Louisiana, Lafayette  
LA 70504, U.S.A.

Towards a better understanding  
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- Seiichi Uchinami  
Faculty of Engineering  
Osaka University  
Yamada-Kami, Suita  
Osaka 565, Japan

A model of topological  
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- Giovanni Neri  
Istituto di Automatica  
Viale Risorgimento  
2, Bologna, Italy

Real time data collection system  
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- William Hutson  
School of Oceanography  
Oregon State University  
Corvallis, OR 97331  
U.S.A.

Climap data base - documentation  
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- Takeshi Kawamura  
Institute of Geoscience  
University of Tsukuba  
Tennodai, Sakura-mura  
Niihara-gun, Ibaraki 305  
Japan

Some problems on data related  
air pollution meteorology
- Masatoshi M. Yoshino  
Institute of Geoscience  
University of Tsukuba  
Tennodai, Sakura-mura  
Niihari-gun, Ibaraki 305  
Japan

Problems of data in local and  
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- N. G. Rambidi  
Molecular Constants  
Research Centre  
Moscow, 117334  
U.S.S.R.

Numerical data and optical  
methods for pollution control

- R. Norman Jobes  
Department of Chemistry  
Tokyo Institute of  
Technology  
12-1 Ohokayama 2-chome  
Meguro-ku, Tokyo 152  
Japan

New developments in infrared  
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- Barbara Mez-Starck  
Section for Structure  
Documentation  
University of Ulm  
Ulm, West Germany

Development of a computer  
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phase
- Valentin A. Koptug  
Institute of Organic  
Chemistry  
Novosibirsk, U.S.S.R.

Organization and possibilities of  
data banks of the "chemical  
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- G. K. Hartmann  
Max-Planck-Institut für  
Aeronomie  
D-3411 Katlenburg-Lindau 3  
P. O. Box 20, West Germany

Problems of non-reproducible data  
due to large growth rates
- M. Spadoni  
SOGESTA S.p.A.  
61029, Urbino, Italy

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data
- G. Bucci  
Istituto di Elettronica  
viale Risorgimento 2  
40136 Bologna, Italy

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for reliable collection and  
processing of air traffic  
real-time surveillance data
- Carlos Jaschek  
Centre de Donnees  
Stellaires  
11, rue de l'Universite  
6700 Strasbourg, France

Data banks in astronomy
- Bernard Hauck  
Institut d'Astronomie  
Universite de Lausanne  
1290 Chavannes-des-Bois  
Switzerland

Dissemination of data in astronomy  
and astrophysics
- Ichiro Fukuda  
Kanazawa Institute of  
Technology  
Ohgigaoka, Nonoichi-cho  
Ishikawa 921, Japan

Compilation of machine-readable  
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- Yoichi Terashita  
Computer Center  
Kanazawa Institute of  
Technology  
Oogigaoka, Nonoichi-cho  
Ishikawa 921, Japan

Data management techniques  
applied to machine-readable  
astronomical data

- Stephen R. Heller  
US EPA, MIDSD, PM-218  
401 M. Street, SW  
Washington, D.C. 20460  
U.S.A.

Economics of on-line data  
dissemination

- Michael S. Keplinger  
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